POWER

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Candid Chats

The Power of Ambition

Do you want to be more successful, earn more money, occupy a better position in life? You can do it. Your life is in your making. Be you what you may, you can rise to a height limited only by your ambition and your energy.

You say you are now putting in the better part of the day in a hot and stuffy power plant. That should not deter you. You are AMBITIOUS. Can't you feel an invisible something forcing you upward, almost against your conscious will, continually urging you onward and onward? You know that to attain a higher position, you will have to make yourself more valuable to your employer and to the world. One way to do this is to study good books; subscribe to the best technical magazines; so that you may keep informed of the latest progress in your business.

Your limit is not the Chief Engineer's desk. It is but a step from that to an executive position. Once you start working in earnest, you will be surprised at THE POWER OF AMBITION.

Every circumstance will be a spur and an incentive to greater effort; if adverse, it will only make you clench your teeth and fight the harder. But first you must fix in your mind what object you are going to attain; choose a definite goal, so that you can concentrate all your efforts toward it.

In this fight for advancement, it is very much as in actual warfare — once the general discovers where the enemy lies hidden, he can muster all his forces to overcome them, without having to spread them over a large area with the consequent weakening of his power.

Be sure to set your mark high enough. "Hitch your wagon to a star." And above all, don't allow yourself to become discouraged at the first obstacle you meet.

Any weakling can lie down and quit, but it takes a MAN to be up and at it when he encounters an obstruction in his path to success. Just as the athlete becomes stronger by continued physical exertion, so you will become stronger in character by overcoming the obstacles confronting you.

Now then, FIRE UP! See what you can do!

(Contributed by Herman Block, Brooklyn, N. Y.)

Power Plant of New Lumber Exchange Building

By Thomas Wilson

SYNOPSIS—A direct-current plant with 600-kw. generating capacity and 800 hp. in Scotch marine boilers. Engines equipped with poppet valves operated by eccentrics on a layshaft. Small steam piping and large receiver separators a feature. An excellent switchboard on which vertical circuit-breakers replace the usual switches and fuses on feeder panels. Gravity ventilation for engine and boiler rooms.

On May 2, 1914, the work of tearing down the old Roanoke Building at the corner of Madison and La Salle St., Chicago, was started, and at the present writing the Lumber Exchange Building, which has taken its place, is practically complete. The latter structure is a 16-story office building, 217 ft. tall from sidewalk to cornice, erected by the L. J. McCormick estate. The steelwork was designed for 20 stories, and the supporting risers have been carried through the roof, so that if desired an extension may be easily made at any time. Below the sidewalk there is a basement and two sub-basements containing the engine and boiler rooms, the floor of the latter being 45 ft. below the street level. The two levels for the power plant were necessary, as the adjacent building rests on a floating foundation, within 30 ft. of which deep excavation was not permitted. The frontage on La Salle St. is 135 ft. and on Madison St. 101 ft. At the inner corner a 47x75-ft. light-shaft above the third floor reduces the outline to an L shape. The building is of substantial construction throughout and, with its artistic terra cotta exterior, presents a handsome appearance.

To supply this building with heat, light, and power for the electric elevators is the purpose of the power plant located in the sub-basements. This plant contains a number of interesting features such as are indicated in the synopsis. Generally speaking, it is substantial and up-to-date in every respect. For the services for which it is intended the plant has been laid out to operate at high economy, and a special effort has been made to hold the labor and maintenance items to a minimum.

It has been estimated that the load will run close to 300 kw. during the heating season and up to 200 kw. in the summer months. Consequently, units of these capacities and four boilers rated at 200 hp. each were installed. At any one time two of these boilers will easily supply sufficient steam for the generating units and there will be two in reserve. Exhaust steam will be used for heating, and to furnish a sufficient supply during nights and holidays a specially designed 100-kw. turbo-generator with a high water rate will carry the load.

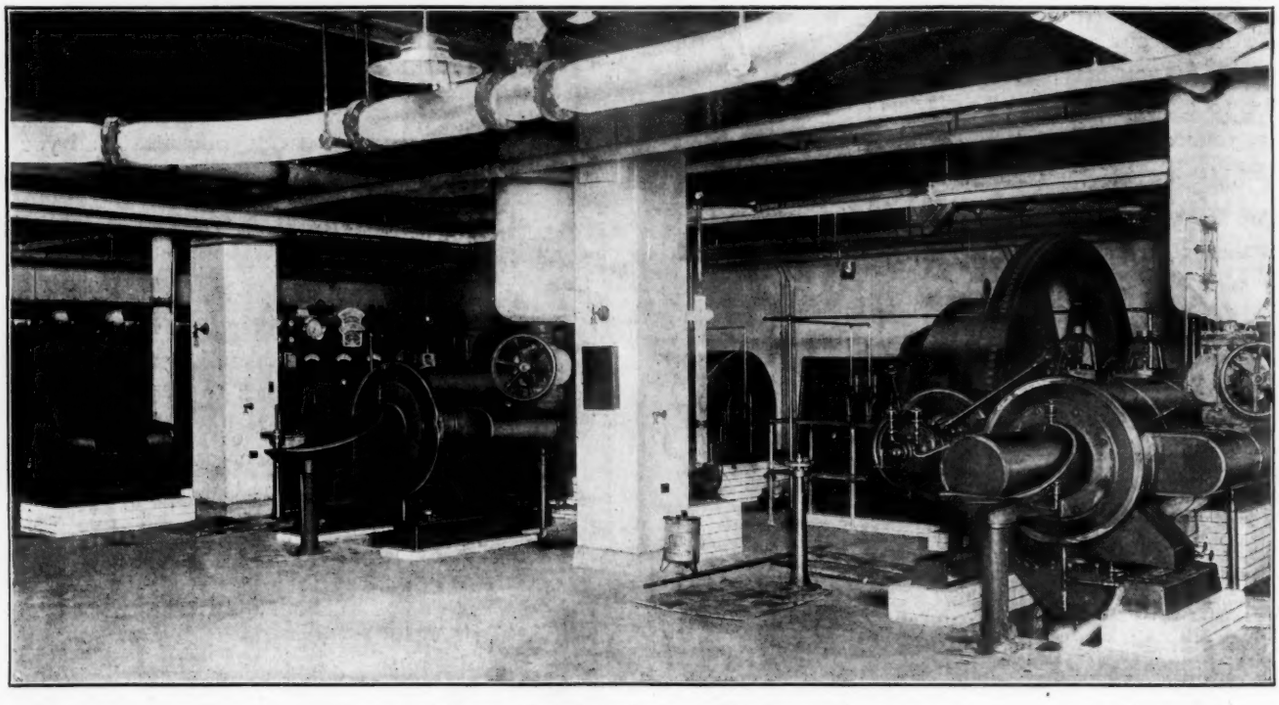


Fig. 1. Engine Room of Lumber Exchange Building

Boiler Installation

After due consideration of the magnitude and variable character of the load, it was decided to install units of 200-hp. capacity. These boilers are of the Scotch marine dry-back type, 96 in. in diameter and 16 ft. long. By means of a sheet-iron thimble lined with firebrick each boiler is connected with a dutch-oven furnace equipped with a top-feed stoker. Eventually, the air supply for the furnace will be drawn around this thimble and introduced into a closed ashpit. The stoker is provided with crushing rolls at the bottom of the magazines, which not only crush the coal, but also force it onto the grates. The latter

are V-shaped and are inclined at an angle of 45 deg. The actual grate surface is 53 sq.ft. and 50 per cent. of this is air space. To the 1595 sq.ft. of heating surface in the boiler, the grate area bears a ratio of 30.1 to 1. This is considerably lower than commonly allowed, but the boilers are rated on 8 sq.ft. of surface per horsepower and the large air space in the grate permits a high rate of combustion.

The boilers are designed for 200 lb. pressure, but are operated at 160 lb. gage. They are covered with magnesia block, and with a handhole on each side and one on the top of the boiler, are easily accessible so that cleaning may be effected in a comparatively short time. There is little loss from radiation. The boilers will hold their heat well over night and by the omission of the usual brick setting air infiltration is obviated. High economy should be obtained, and with a furnace which can be hand-fired if necessary, reliable and continuous service may be expected. It is planned to run two boilers during the day and bank one at night. By forcing, one boiler might handle the load, but two are carried on the line to guard against a possible interruption of the service. A point worthy of consideration is that all repair parts that these boilers may need can be conveyed to the boiler room through the elevator shaft.

Natural draft is supplied by a steel stack rising about 300 ft. above the boiler-room floor. The shell is 6 ft. in diameter, but a 4-in. lining all the way up reduces the bore to 5 ft. 4 in. A powerful draft is thus available, and the proper intensity over the fire is obtained by damper control. Differential draft gages with four connections—one to the ashpit, one over the fire, one at the rear of the boiler and one to the uptake—make it possible to read the draft at the particular points just mentioned or the drop in draft through the furnace and boiler. The smoke flue, which is immediately in front of the boiler and runs over the rear ends of the furnaces, is of tapering section. It has one right-angled turn and at the stack its area is 27 sq.ft. This may be compared to 22 sq.ft., the free area of the stack, and to a connected grate surface of 212 sq.ft. To the last figure the breeching area bears a ratio of 1 to 8, but as it is not expected that more than two boilers will be operated at any one time, the ratio actually becomes 1 to 4, which is close to standard practice.

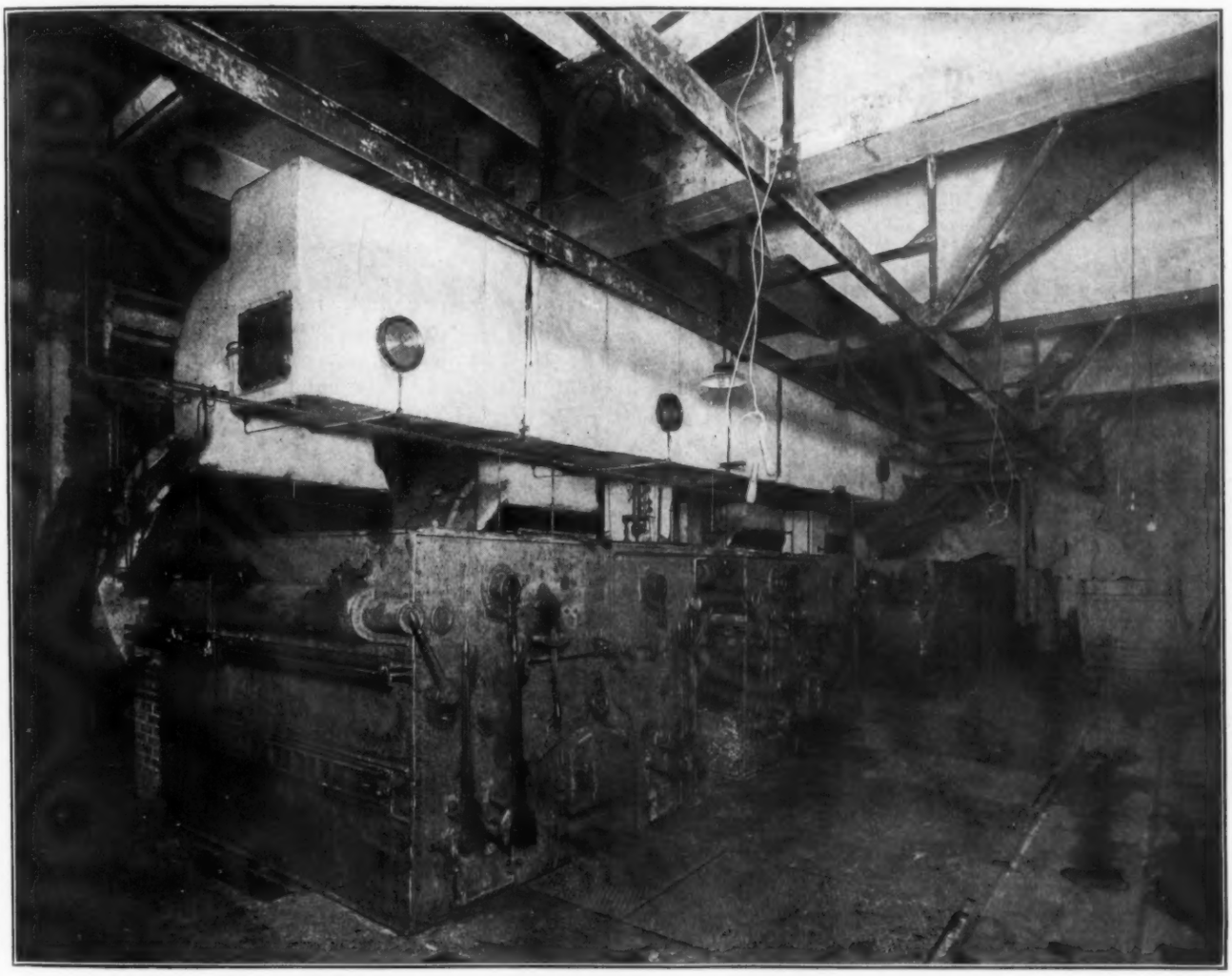


FIG. 2. BOILER INSTALLATION WITH ONE OF TUNNEL CARS AT THE RIGHT

Feed water may be drawn from the heater or the city mains and is forced to the boilers by either one of two simplex pumps. To guard against interruption of the feed, the supply lines to the boilers are in duplicate and are cross-connected so that parts of either line may be cut out of service if desired. Provision has also been made for weighing tanks to be used in testing the boilers or as a check on the V-notch meter.

Illinois screenings is used as fuel. It may be delivered by wagon or through Chicago's underground freight tun-

nel. There are four chutes from La Salle St., each discharging to a 50-ton reinforced-concrete bunker, one for each boiler. When the coal is delivered through the tunnel, the cars are run in on the boiler-room floor and dumped into a hopper beside the track. From this hopper a screw conveyor forces the coal to a bucket elevator, which at the top of the boiler room turns at right angles and delivers the coal to any one of the four bunkers. In the horizontal run the buckets scrape the coal along a

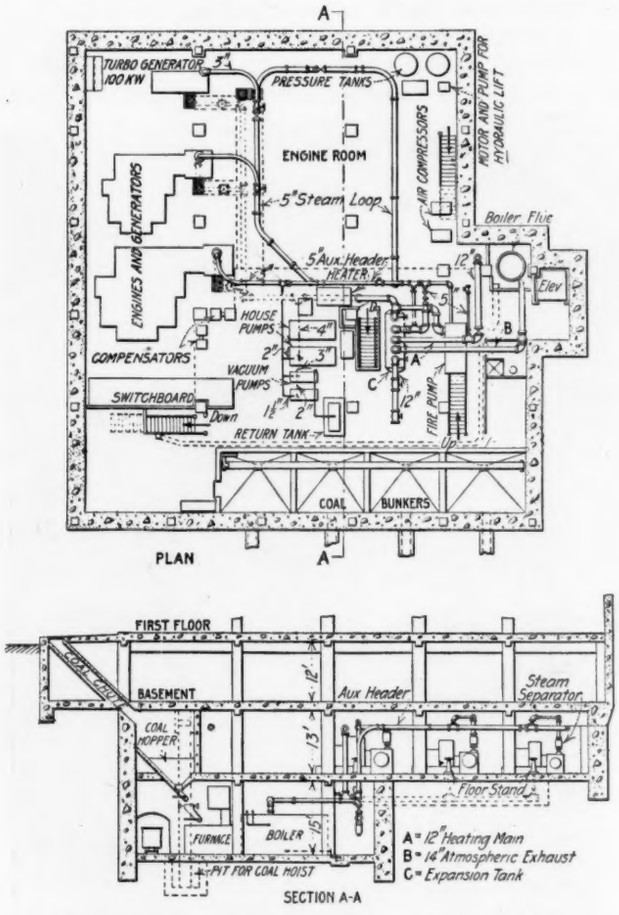


FIG. 3. PLAN OF ENGINE ROOM AND ELEVATION THROUGH PLANT

trough and through gates in the bottom of this trough, which are operated by handwheels in the engine room, and discharge it to any one of the bunkers. A track scale weighs the coal on its way to the magazines of the stoker. Ashes are shoveled directly into the tunnel cars, which at stated intervals are removed from the plant.

To prevent spoiling the fires in the boiler furnaces, a rubbish burner has been provided. This is a hot-water boiler with a coal grate below and a tube grate above for the paper and other waste from the building. Water for house service passes through this boiler and absorbs the heat from the waste material. Additional heat is supplied by closed heaters in the engine room, provided with exhaust-steam connections and temperature regulators.

From the third floor down all sewage must be raised to the street. For this purpose a duplex motor-driven sewage ejector has been provided in the boiler room. To care for an excessive quantity of water, a turbine-driven centrifugal pump with a 10-in. suction and 5-in. discharge, has been installed. The sewage must be elevated about 40 ft.

In the selection of the generating units, economy and regulation were the first considerations. With an electric-elevator load the variations are excessive and close regulation is necessary to prevent the fluctuations showing in the lights. Poppet four-valve engines were chosen as the prime movers for the two larger units. The valves are of the balanced type and are positively operated by cams oscillated by eccentrics on a layshaft. Between the two eccentrics an inertia governor mounted on the layshaft controls the speed. On its way to the inlet valves the steam passes over the ends of the cylinder, tending to reduce initial condensation and increase the economy of the engine.

For these units, which are of 300- and 200-kw. capacity respectively, the guaranteed steam consumption at full load is 20.8 lb. per i.hp.-hr., but from results obtained from engines of the same type a lower rate is expected. The generators are two-wire, 240-volt machines specially provided with extra large air gaps and heavy series windings to care for the heavy inrushes of current caused by the electric-elevator load. Compensators provide for three-wire distribution on the lighting. The engines are equipped with an automatic oiling system with an overhead tank and drainage from the bearings to a filter in the boiler room. Cylinder lubrication is effected by three-feed pumps driven from the layshaft. One feed goes to the throttle and one to each end of the cylinder. A reducing motion attached to a standard on the guide barrel and driven by the crosshead is a permanent fixture of the engine.

During the summer months it is the intention to run the smaller engine unit. In the heating season the large

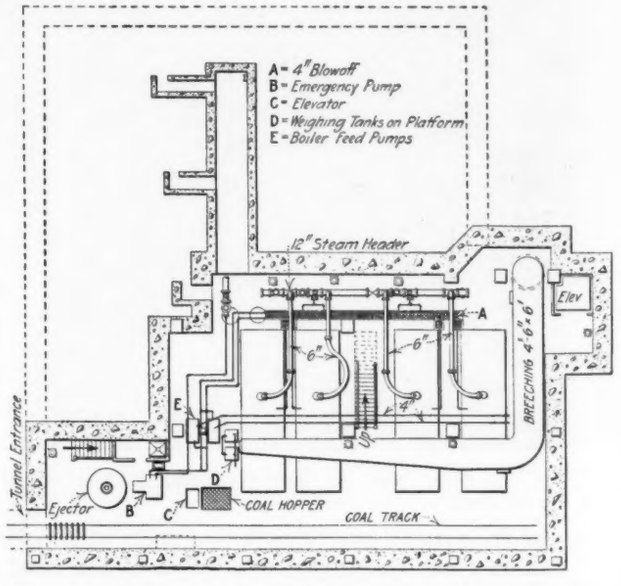


FIG. 4. PLAN OF BOILER ROOM BELOW THE ENGINE ROOM

unit will carry the load. From preliminary estimates it was figured that during the day there would be sufficient exhaust steam for heating, as in addition to the engines there are a number of steam-driven pumps. At night, however, and on holidays the load will be light, and rather than supply the live steam which would be necessary for heating through a reducing valve, it was deemed advisable to utilize a turbo-generator with a water rate purposely made high by the addition of nozzles so

that sufficient exhaust steam would be available for heating. In other words, the turbine will act as a reducing valve and at the same time generate all of the current that is needed.

The unit consists of a 150-hp. single-stage turbine directly driving a 100-kw., 240-volt, direct-current generator at a speed of 2200 r.p.m. It was built especially to meet the requirements of the particular class of service existing in this plant. The governing device is so designed as to give practically constant speed under all conditions of load. At this writing the turbine has not been installed. A fuller description of this unit will be given when the results of the acceptance tests are available.

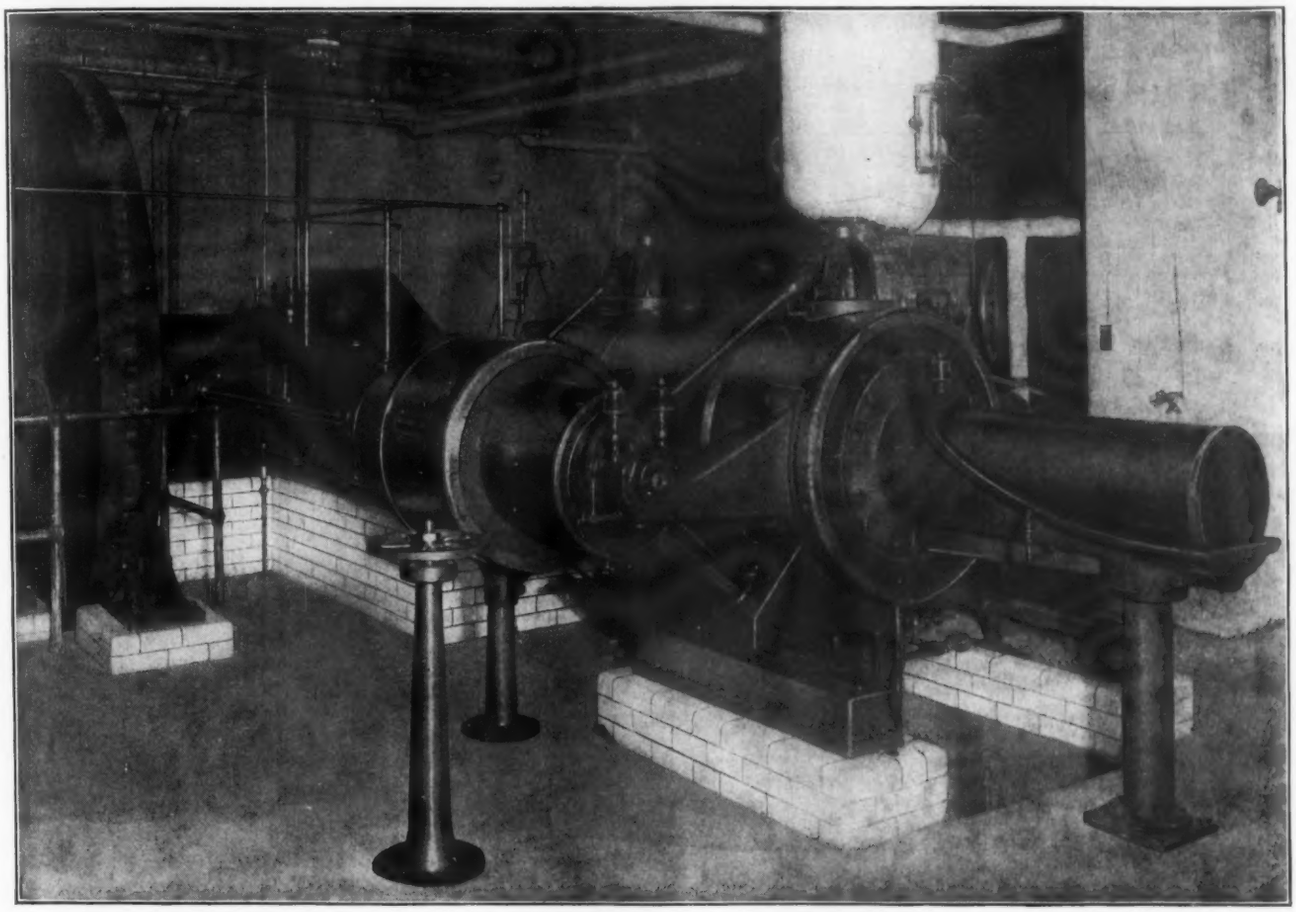


FIG. 5. ONE OF THE POPPET FOUR-VALVE ENGINES

PIPING ARRANGEMENT

From the accompanying line drawings the piping arrangement will be evident. Six-inch boiler leads connect with a 12-in. header at the rear of the boilers. Risers lead up to a 5-in. loop in the engine room and to an auxiliary header supplying the boiler-feed, fire, house and vacuum pumps. From this header there are also reducing-valve connections to the expansion tank, so that live steam may be supplied to the heating system when the turbine unit is not operating. If a large amount of live steam is required, the 5-in. reducing valve will be used. For a small quantity to supplement the exhaust-steam supply, a 1½-in. reducing valve has been provided. This relieves the larger valve and prevents the wire-drawing that would occur with a small quantity of steam passing through. The 5-in. loop now supplies the smaller engine and the turbine and is also intended for a 150-ton refrigerating machine which may be installed at some time in the future. All condensation from the loop and the auxiliary header returns directly to the main header in the boiler room, and from here it is trapped to the heater.

The remarkable feature about the piping is the small leads supplying the generating units. A 3-in. pipe supplies the 300-kw. machine, and the lead to the smaller engine is only 2½ in. in diameter. A 25-per cent. overload on the engines will require a steam velocity of about 8000 ft. per min. in these pipes. As standards go, this velocity might be considered excessive, but as the pipes are used in conjunction with receiver separators four times the volumes of the cylinders and large throttle valves, not the slightest trouble has resulted during the short time the plant has been in operation. The loop from which the small engine draws its supply is suspended from rings in the ceiling by means of turnbuckle hangers. It is not even anchored, and yet there is no evidence of vibration due to the cutoff of the engine. The reasons for this small piping are, of course, less radiation, less condensation and a lower initial cost for piping and fittings. As the engine throttles are 8 and 7 in. respectively, the supply of steam is not curtailed, and any inequalities in pressure which might result with the usual installation are smoothed out by the large separators.

Through a tunnel under the engine-room floor the exhaust piping passes out into the boiler room, thence up to the heater, which is on the engine-room floor, and on to the expansion tank and the hot-water heaters for house service. The relief valve to atmosphere is set for a back pressure of 2 lb.

A feature of interest is the separation of the V-notch meter and the feed-water heater. The connections are so arranged that either may be cut out of service without affecting the other or both may operate independently; that is, the meter may measure the water to one boiler which is perhaps running on test, while the water for the other boilers is drawn directly from the heater. Piping connections have also been made so that the returns from the heating system or from any or all traps can be measured separately. Ordinarily, of course, the water passes from the heater to the meter, and with this independent arrangement the exact quantity is recorded just as it flows to the boiler. When the meter is installed in the heater, the flow over the V-notch may be greater or less momentarily than the amount of water fed to the boilers. The seventh floor. A 5-in. pipe supplies the main floor and the basement.

Ventilation for the basement and the toilets is provided, and effected by motor-driven exhaust fans. The engine and boiler rooms depend on the pull of the stack for their supply of fresh air. Cold air from above is drawn down through the elevator shafts and stairways and in this particular case also through two ducts leading to gratings in the sidewalk. Fresh air passes across the engine and boiler rooms on its way to the furnaces, so that the rooms are maintained at a comfortable temperature. The stack has been erected in a square casing, with considerable clearance between the walls and the shell. Consequently, there is a free passage for the air from the boiler room to the roof, so that the ventilation is continuous

FIG. 6. VACUUM AND HOUSE PUMPS, OPEN HEATER AND V-NOTCH METER

flow over the weir is the amount recorded on the chart, so that instantaneous readings and the actual boiler feed may not check, although either system over a period of time will record the same amount.

Another feature, not as common as it should be, is the provision of a small auxiliary pump to relieve the fire pump. Any slight unbalancing of pressure is cared for by the small pump. The fire pump is maintained ready for instant duty and is automatically cut into service when the capacity of its auxiliary is exceeded.

HEATING AND VENTILATION

To heat the building, 21,408 sq.ft. of direct radiation has been provided. It is served by a vacuum system of the Van Auken type, with overhead distribution. Everything above the main floor is taken care of by a 10-in. riser that distributes downward from the attic on the

whether the dampers to the furnaces are open or closed. The same system has been applied to the McCormick Building with wonderful success. The engine and boiler rooms are exceptionally cool. The air currents were studied by means of silk flags hung from wires stretched across the room. In this way the openings for air admission were properly located and any necessity for deflectors to send the air to all parts of the room was made evident. The same procedure must be followed in the new building under discussion. The air currents common to the building must be established, and proper methods adopted to produce uniform distribution and satisfactory ventilation.

To heat the hallways the same principle was applied, but this time utilizing the pull of the building. Vento coils are placed within inclosures off the hallways, and through grills fresh air from the street is drawn over the heating surface into the hallways. This relieves the dif-

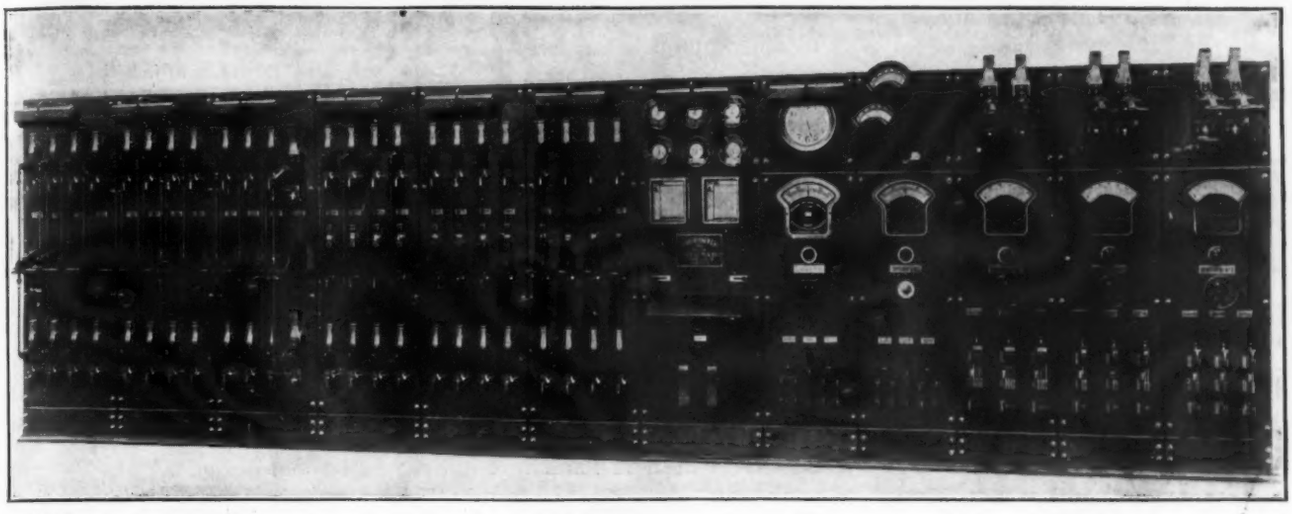


FIG. 7. FRONT VIEW OF SWITCHBOARD, SHOWING VERTICAL-TYPE CIRCUIT-BREAKERS

ference in pressure between the interior and the exterior of the building, and when the doors are opened no great quantity of cold air is drawn in. The hall is maintained at a satisfactory temperature, and in this regard the usual difficulties are eliminated.

ELEVATOR DETAILS

The elevators for the building are of the 1 to 1 gearless traction type. Five are passenger cars having a capacity of 2500 lb. at a speed of 550 ft. per min. The sixth elevator is for freight service. Its capacity and normal speed are the same, but heavy lifts may be effected at slow speed by the use of an extra 6000-lb. counterweight. All of the cars are driven by 220-volt, 34-hp. motors having a rated speed of 58.5 r.p.m. The cars have interlocking doors that must be closed to within 4 in. before motion is possible. There is also a special board for recording the stops and signals.

For service between the main floor and the basement there is a 4000-lb. hydraulic lift, operating on a water pressure of 125 lb. The equipment, consisting of pressure tanks, a motor-driven pump and a small air compressor belted to the pump shaft, is located in the engine room. Near-by is a small air compressor, which is motor-

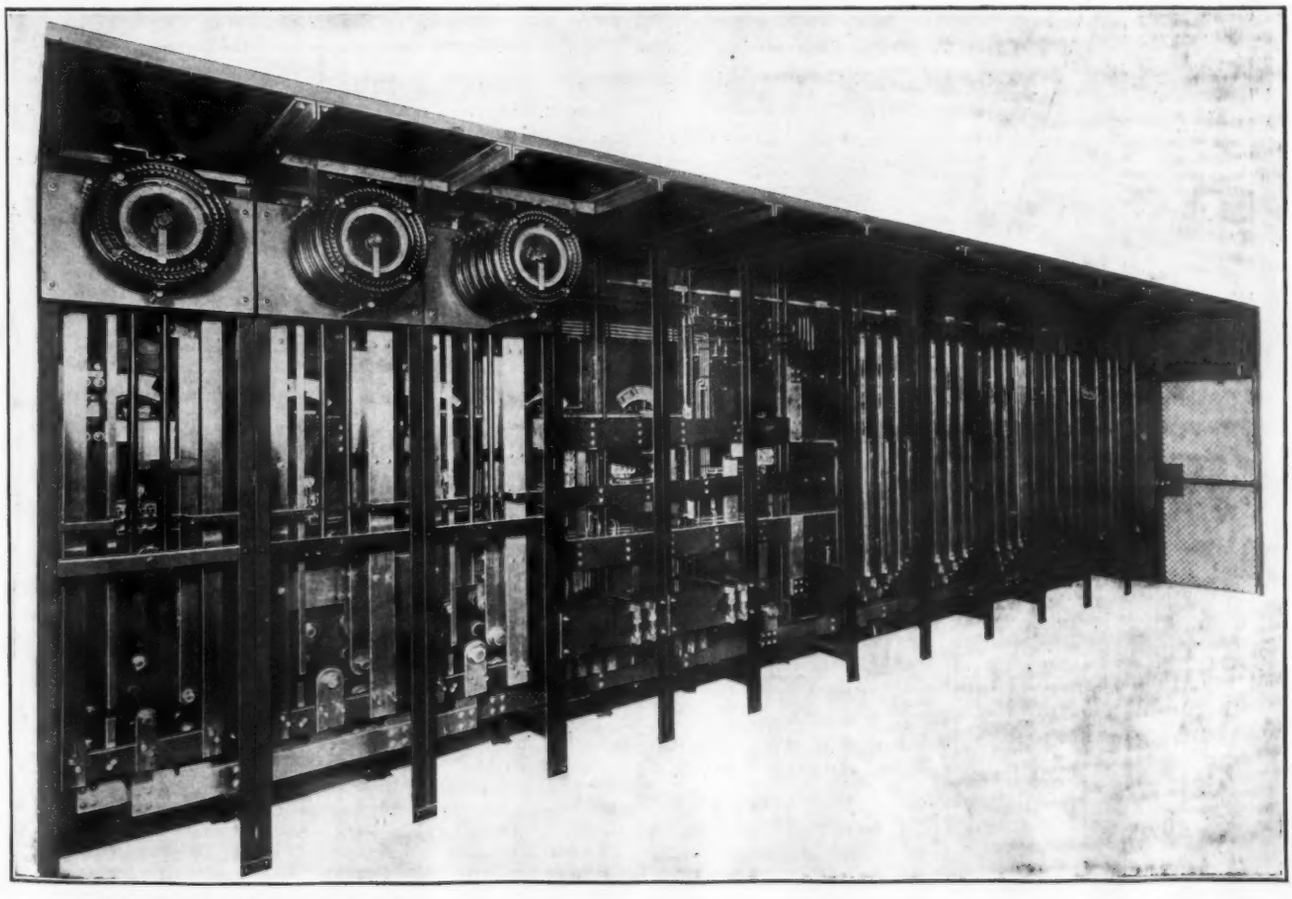


FIG. 8. REAR VIEW OF SWITCHBOARD, SHOWING SIMPLICITY OF COPPER WORK BEHIND FEEDER PANELS

driven and supplies air at 100 lb. pressure for blowing the dust from the switchboard, generators and other equipment of the plant.

Switchboard Equipment

The switchboard is an excellent example of a modern installation. It is equipped with the latest instruments and lighted by means of reflectors above the panels, but the feature which distinguishes it from the ordinary is the use of vertical-type circuit-breakers on the feeder circuits. These breakers are connected directly to the busbars so that intermediate connections and fuses are eliminated. This results in an unusually simple arrangement back of the board and effects a considerable saving in copper. The circuit-breakers are of the interlocking type, nonclosing on overloads, and as the busses may be run close to the board, studs of standard length are used.

For lighting, the distribution is three-wire and the power circuits are two-wire. As a consequence two- and three-pole circuit-breakers are employed, but for the sake of uniformity the positive poles at the top, the negative poles at the bottom and the operating handles at the center have all been placed in line. The generator panels are equipped with overload, no-voltage and time-limit release-type circuit-breakers in which the poles are arranged horizontally. The three busses are carried directly across the board to the lighting panels and independent positive and negative busses extend all the way across to the power panels. The two sets of busses are brought together by means of a suitable tie-switch. It is thus possible to carry the power and lighting loads on separate machines or on one machine, as desired. The lower stud of each breaker is connected to a bus. The upper stud is carried back of the bus, and a bar connection extends directly down to the terminal board. It may be noticed that all of the feeders terminate on panels at the bottom of the switchboard and that no flexible copper leads are used save those for the instruments. It is evident that the copper work is all straight-run and the arrangement unusually simple.

Frank H. Getchell, electrical engineer for Holabird & Roche, architects for the building, is the designer of the switchboard and the remainder of the electrical equipment. The mechanical equipment of the plant and building was laid out by John B. Blake, mechanical engineer for the same company, under the supervision of M. T. Kimman, chief engineer of the McCormick estate. C. G. Harding is the chief operating engineer in charge of the plant.

PRINCIPAL EQUIPMENT OF LUMBER EXCHANGE BUILDING PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Scotch-marine	200-hp.	Generate steam	160 lb. press., natural draft stokers	Springfield Boiler & Manufacturing Co.
4	Stokers	Side-feed	53 sq.ft. grate	Serve boilers	45-deg. grates, 50 per cent. air space	McKenzie Furnace Co.
2	Pumps	Simplex	7x6½x10-in.	Feed boilers	160 lb. steam press.	(Marsh) American Steam Pump Co.
4	Draft gages	Differential		Measure boiler draft	Four connections	L. M. Ellison
1	Rubbish burner	Hot-water boiler		Burn waste from building	Water head 130 lb	Kewanee Boiler Co.
1	Conveyor	Screw	10 tons per hr.	Coal from hopper to elevator	Motor-driven	Webster Engineering Co.
1	Conveyor	Bucket	10 tons per hr.	Coal from screw conv. to bunkers	Motor-driven	Webster Engineering Co.
1	Scale	Track		Weigh coal to furnaces		Webster Engineering Co.
1	Sewage ejector	Duplex-electric		Raise sewage to sewer	Operated by 2 C.-W. 7.5-hp. motors	Yeomans Bros. Co.
1	Pump	Centrifugal	10-in. suction, 5-in. discharge	For emergency sewage	Driven by Wait turbine	Henry R. Worthington
1	Engine	Four-valve poppet	22x32-in.	Main generating unit	160 lb. steam, 150 r.p.m.	Nordberg Manufacturing Co.
1	Generator	Direct-current	300-kw.	Main generating unit	240 volts, 150 r.p.m.	Crocker-Wheeler Co.
1	Engine	Four-valve poppet	18x30-in.	Main generating unit	160 lb. steam, 150 r.p.m.	Nordberg Manufacturing Co.
1	Generator	Direct-current	200-kw.	Main generating unit	240 volts, 150 r.p.m.	Crocker-Wheeler Co.
1	Turbine	Single-stage impulse	100-kw.	Main generating unit	160 lb steam, 2200 r.p.m.	H. H. Wait
1	Generator	Direct-current	100-kw.	Main generating unit	240 volts, 2200 r.p.m.	H. H. Wait
2	Balance sets		115 volts, 20 amp 115 volts, 40 amp	Balance three-wire system	1600 and 1150 r.p.m.	Crocker-Wheeler Co.
1	Switchboard*	Slate	12-panel	Control and distribution current		Cuthbert Electric Manufacturing Co.
24	Circuit breakers	I.T.E. "Directite"		Feeder panels		The Cutter Co.
3	Circuit breakers	I.T.E.		Generator panels		The Cutter Co.
1	Heater	Sorge-Cochrane, open	500-hp.	Heat feed water	Exhaust steam	Harrison Safety Boiler Works
1	Meter	V-notch		Record boiler feed		Harrison Safety Boiler Works
2	Heaters	Closed	1200-gal. per hr.	Hot water for house	Exhaust steam	W. Baragwaneth & Son
2	Pumps	Vacuum	8x12x12-in.	Heating system	160 lb. steam	International Steam Pump Co
1	Pump	Simplex	7x6½x10-in.	House service	160 lb. steam, head 130 lb	American Steam Pump Co.
1	Pump	Triplex	6x8-in.	House pump	Driven by 15-hp. C.-W. motor, 800 r.p.m.	Deane Steam Pump Co.
1	Pump	Underwriters	14x7½x12-in.	Fire service	160 lb. steam	International Steam Pump Co.
1	Pump	Duplex	6x4x6-in.	Auxiliary to fire pump		International Steam Pump Co.
1	Air compressor	Single-stage	8x8-in.	Comp. air for cleaning	Driven by 15-hp. C.W. motor, 800 r.p.m., 100 lb. press	Chicago Pneumatic Tool Co.
6	Elevators	1 to 1 gearless traction	2500-lb.	Serve building	550 ft. per min., 34-hp. motors	Otis Elevator Co.
1	Lift	Hydraulic	4000-lb.	First floor to basement	Water pressure 125 lb.	Otis Elevator Co.
1	Pump	Triplex	4x60-in.	Serve hydraulic elevator	Driven by 5-hp. C.-W. motor	Deane Steam Pump Co.
1	Oiling system	Pump and gravity		Lubricate generating units	Filter, gravity tank and complete system	Richardson-Phenix Co.
2	Cylinder lubricators	Three-feed		For main engines	Driven from layshaft	Richardson-Phenix Co.
7	Cylinder lubricators			For steam pumps		Richardson-Phenix Co.

*Weston ammeters and voltmeters, Sangamo wattmeters, Esterline graphic ammeter and voltmeter.

B.t.u. to Calories—To convert B.t.u. per pound to calories per kilogram, divide the number of B.t.u. by 1.8; to convert calories per kilogram to B.t.u. per pound, multiply the calories by 1.8.

Pressure Drop in Steam Lines is comparable with line drop in electric distribution systems, which is known to be energy lost, but the desired terminal voltage is obtained and the drop compensated for by a slight increase of voltage at the source or apparatus designed to use the lower voltage. Feeders or steam lines large enough to cause no drop are not feasible; the amount of drop to be permitted is the variable quantity. The greater radiation loss from excessively large steam lines has no counterpart in the electric-distribution analogy.

Core Loss in Series Motor

By T. M. Robie

SYNOPSIS—The article describes a method of finding the core loss of a series motor by test with the aid of a motor-dynamometer.

The losses in a motor or generator are: The field loss F, due to the heat generated in the field windings by the field current; the armature loss A, due to the heat generated in the armature windings; the loss in the brushes; stray power loss S, which includes eddy current and hysteresis losses, chiefly in the armature core; and losses due to friction in the bearings, at the brushes, and windage, or air friction.

The heat losses can be calculated from the equation,

$$watts\ lost = I^2R$$

where R is the resistance of the part under consideration and I the current flowing in that part. The resistance should be that at running temperature.

Stray power loss cannot be accurately calculated by any simple data and is usually determined by experiment. In this article the author will give a simple and reasonably accurate means of finding the core loss in a series motor. It is necessary to know all the losses mentioned in order to find the efficiency of a motor or generator. Core-loss tests are made by the manufacturers on one machine for

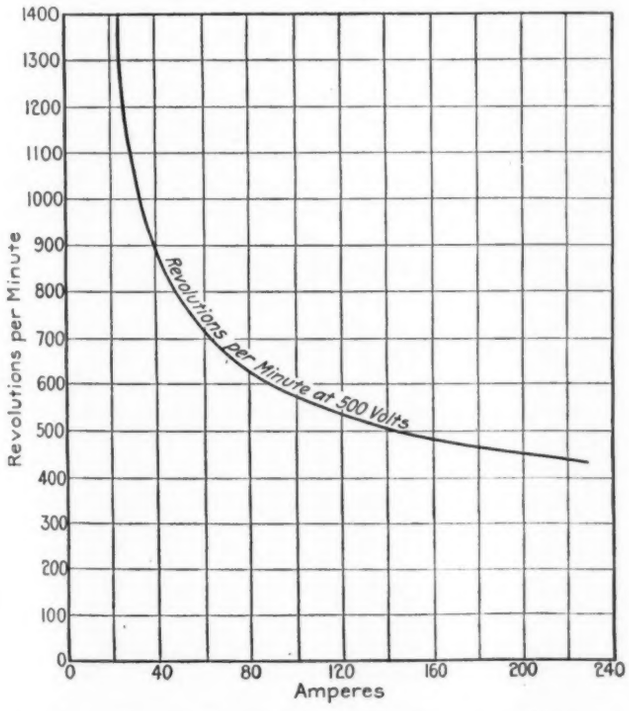


Fig. 1. Speed Curve for 500-Volt Series Motor

each type and class, and hold, with but slight variations, for all machines of the same size and design. While it is usually impractical to make these tests outside a laboratory, still it is interesting to know how they are carried out. Following is the method employed by one of the largest manufacturers of electrical machinery in this country:

The motor or generator under test is mounted on the test stand and is connected by means of a sleeve coupling to a similar motor which runs as a generator and furnishes the load. Holding the motor voltage constant, the load is varied from about 30 to 175 per cent. of normal, and the corresponding speeds are carefully observed.

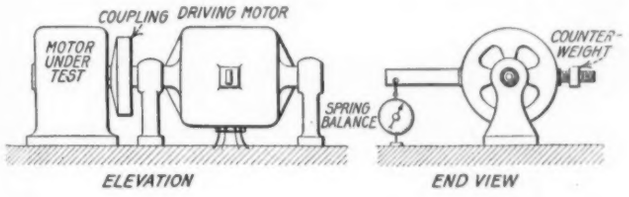


Fig. 2. Showing Driving Motor and Bearings which Allow Frame to Turn About Its Axis

From these data a speed curve is obtained having revolutions per minute as ordinates and current, or load, as abscissas; such a curve is shown in Fig. 1.

The motor is next disconnected from the position mentioned and is connected to a motor dynamometer, as shown in Fig. 2. The motor of the latter is mounted on ball bearings so that the frame is free to turn as well as the armature. A lever arm is attached to the side of the frame, and from this a spring-balance is suspended, the other end of the balance being fastened to the floor. This spring-balance furnishes the force necessary to keep the frame from revolving. The machine under test is then run as a separately excited generator operating at zero load.

About five speeds are selected from the speed curve, and runs are made at each, using five different field excitations for each speed. At the lower speeds the field current on the generator will, of course, have to be higher than at high speeds. Having decided upon the speeds and corresponding field excitations, the field of the motor under test is completely demagnetized by means of a reversing switch installed for that purpose, and the driving motor is started at the lowest speed decided upon. The set is now run until the reading upon the spring-balance is constant. This first reading takes care of all friction losses in the driving motor as well as the motor under test.

The maximum field current is now thrown on and, keeping the speed constant at the first value, the pull on the spring-balance is noted. The four other values of field current are applied consecutively and the corresponding spring-balance readings recorded. The fields are then demagnetized as before by momentarily reversing the field current and a second friction reading is taken, which should check exactly with the first. This process is simply repeated for the higher speeds and their correspondingly lower field currents.

The watts loss in the armature can now be calculated. The net pull on the spring-balance, that is, the reading with the field excited minus that with the demagnetized field, is a measure of the watts lost. The length of the arm from the spring-balance to the center line of the

motor shaft can be measured, and the other values in the equation

$$Watts = \frac{2\pi l n W}{33{,}000} \times 746$$

are known, where

l = Length of the lever arm in feet;

n = Revolutions per minute of the driving motor;

W = Net pull on the scales in pounds.

From the data thus obtained five curves may be drawn, one for each speed, having watts for ordinates and field current for abscissas. These should be drawn on the same curve sheet as was used for the speed curve; see Fig. 3.

The core-loss curve may now be readily drawn in. Suppose it is desired to find the point where the core-loss

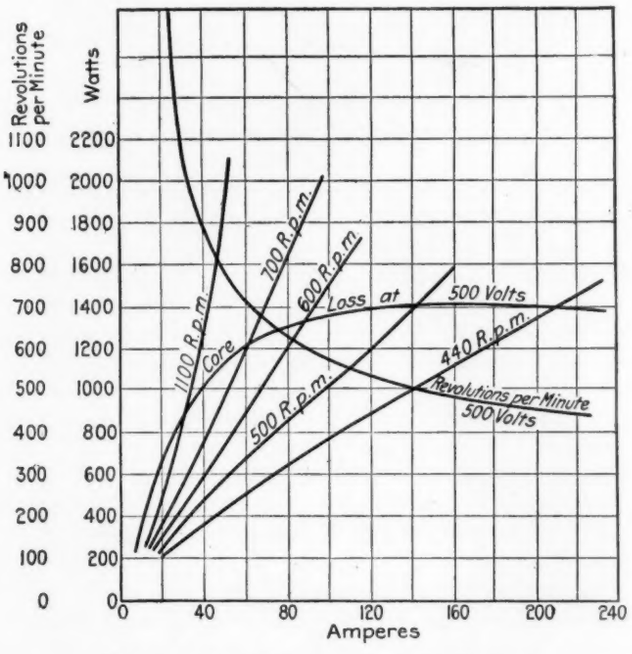


FIG. 3. CORE-LOSS AND SPEED CURVES

curve crosses the 500-r.p.m. curve. Find the field current corresponding to 500 r.p.m. from the speed curve; this is about 140 amp. The point where this field current crosses the 500 r.p.m. curve will be one point on the core-loss curve.

A somewhat quicker way, but not as accurate, is to find the field current corresponding to a given speed and then run the motor under test at this speed and field excitation. The pull on the spring-balance is recorded as before and the watts lost calculated. This will give a point on the core-loss curve corresponding to the field current used; other points may be obtained in a similar manner.

The first method is the more accurate inasmuch as any error will quickly show in the core-loss curves taken at constant speed.

As will be seen, the core loss of a series motor varies greatly with load. With a shunt machine, on the other hand, it is practically constant irrespective of load.

The advantage of the method described lies in the fact that the electrical calculations are reduced to a minimum. It is not necessary to know the input to the driving motor or to know what losses there are in it.

The curves here shown are taken from a 50-hp. 500-volt G. E. railway motor.

JUST FOR FUN

AS USUAL, NO MYSTERY WHEN FOUND OUT

On arriving at the plant in response to a distress call from the night man, I inquired what was wrong. He placed his hand gingerly on the low-pressure valve-chest cover and informed me it was hot. It was quite evident from the smell in the room that something was hot. He then told me that the engine had not been running evenly, but he could locate no other "trouble."

Upon examination I found the pedestal bearing hot and the bronze bearing gripping, causing the engine to slow down and then race. The oil drain-cock had been accidentally opened while cleaning the engine, and although the machine had been running over an hour, the so-called engineer had not discovered the lack of oil, but instead was looking for "something mysterious."—*F. E. Wood, Whitinsville, Mass.*

ABSURDITY NOT ALWAYS FUNNY

I read with some amusement the letter by Mr. Newbury in the issue of Mar. 2, under the column headed "Just for Fun," wherein he refers to the blower salesman's remarks. While the statement was absurd, it does not sound quite so funny to one who has had the following experience.

A blower was sold, and the manufacturer was advised shortly afterward that the plant operator could not run the blower because it blew the gases out into the boiler room. Upon investigation he found that the man operating the plant insisted upon opening the blower valve to its full extent, regardless of the amount of air required. As the blower was installed with a fair margin of extra capacity, it was not ordinarily necessary to operate it at its full rate. Still, the fireman thought he ought by all means to do so, even if he spoiled the fire and filled the boiler room with gas. The main thing in his mind was to operate at full speed.

Is this experience any less funny than the other?—*T. L. Hoyt, New York City.*

AS GOOD AS EVER

In the palmy days of the Mississippi River shipping, the captain of one of the crack racing boats, the "Natchez," I think, was preparing to sail up the river from New Orleans, and finding that a rival boat was to sail about the same time, took occasion to impress upon his colored fireman the importance of having a good head of steam at starting time.

A few minutes before time to depart the captain strolled over in front of the boilers and was surprised to note that the steam gage showed exactly zero.

Naturally he wanted to know why in "hellenblazes" and several other things the fireman hadn't got up steam, to which the colored gentleman replied: "Dat's all right, Cap'n, dat thing's done been around once."

The above is a "wheeze" for which the writer can not vouch, on account of its not being true; still, it may interest such readers as have not heard it before. But if the steam gages had the stop pin taken out or were made so they *could* go around the second time we would be willing to believe the story, judging from some known incidents.—*L. A. States, Gastonia, N. C.*

Horsepower Constants for G. E. Type F Steam-Flow Meter

By Hubert E. Collins

SYNOPSIS—This article contains horsepower tables to be used with the G. E. steam-flow meter with several sizes of steam pipes. The tables are not corrected for moisture or for any other inner mechanism than a No. 6.

Chart readings taken from the G. E. Type F steam-flow meter must be computed by the method laid down in the instruction book No. Y 328, Sept., 1913, which also contains diagram No. 11, with the formula as shown herewith.

Meters not having the integrating attachment require considerable computation to figure the daily output registered. In order that the average of a day's run can be arrived at, the chart reading should be figured at least every half-hour. To get the rate of flow at any half-hour period requires four computations. If the factory has a number of meters, the work is considerable.

The accompanying tables are figured for a No. 6 inner mechanism General Electric Type F steam-flow meter for which the constant K_{cp} on the chart is 1.000. To use the tables with any other inner mechanism, multiply the reading from the table by the constant K_{cp} for that one.

These tables do not take into consideration the moisture of the steam or superheat, and any reading from them must be corrected for one of these. This means that it is necessary to multiply by constant K_1.

To illustrate the calculation of one of these figures in the table, let us figure the rated boiler horsepower passing through a 12-in. pipe at 100-lb. pressure, the chart reading being 2.

Then

$K_2 = 0.835;$

$K_3 = 15{,}750;$

$K_{cp} = 1.000.$

$15{,}750 \times 0.835 = 13{,}151$ *lb. of steam per hour rate*

$$\frac{13{,}151}{30} = 438 \text{ boiler horsepower}$$

TABLE 1. HORSEPOWER CONSTANTS FOR "TYPE F." G.E. STEAM-FLOW METER

Gage Pressure	Pipe Sizes 12-In.	10-In.	8-In.	6-In.	4-In	3-In.
20	241	161	95	53	21	12.2
25	260	173	102	57	23	13.2
30	275	183	108	61	24	14
35	288	192	113	64	25	14.6
40	301	201	118	67	26	15.3
45	315	210	124	70	28	16
50	328	218	129	72	29	16.6
55	341	227	134	75	30	17.3
60	354	236	139	78	31	18
65	364	243	143	81	32	18.5
70	375	250	147	83	33	19
75	385	257	151	85	34	19.6
80	396	264	156	88	35	20
85	406	271	160	90	36	20.6
90	417	278	164	92	37	21.2
95	427	285	168	95	38	21.7
100	438	292	172	97	38.9	22.2
105	446	297	175	99	39.6	22.6
110	456	304	179	101	40	23.2
115	464	309	182	103	41	23.6
120	472	315	186	105	42	24
125	483	322	190	107	42.8	24.5
130	490	327	193	109	43.6	24.9
135	498	332	196	110	44.3	25.3
140	506	337	199	112	45	25.7
145	514	343	202	114	45.7	26.1
150	525	350	206	116	46.6	26.6

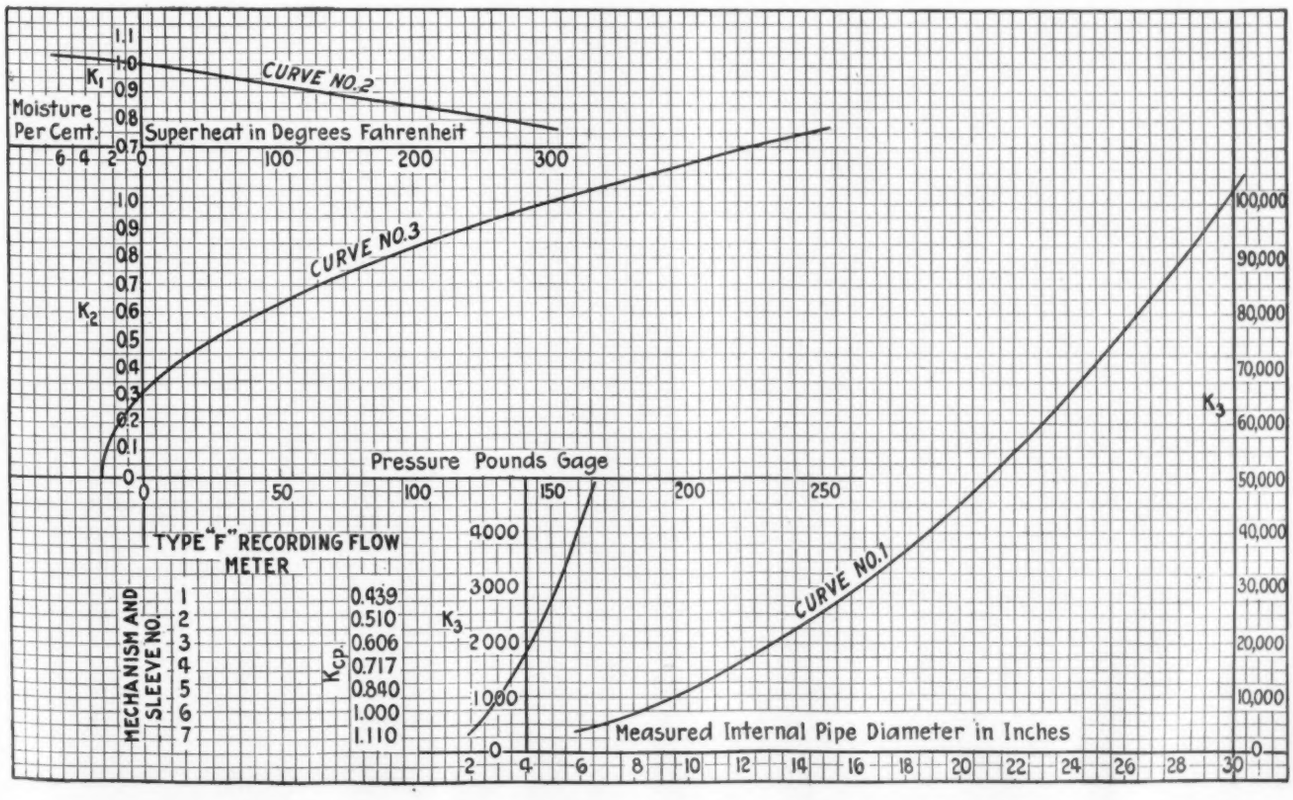


Diagram No. 11, for Use with Type F Recording Steam-Flow Meter

For the purpose of calculating the tables the following constants are taken from the chart:

	K_s Constants
2-in. pipe = 11¼-in. internal diameter	= 15,750
0-in. pipe = 9¼-in. internal diameter	= 10,500
8-in. pipe = 7¼-in. internal diameter	= 6,200
6-in. pipe = 5¼-in. internal diameter	= 3,500
4-in. pipe = 3⅝-in. internal diameter	= 1,400
3-in. pipe = 2¼-in. internal diameter	= 800

K_s

Gage Pressure	Constants	Gage Pressure	Constants	Gage Pressure	Constants
20	= 0.46	65	= 0.695	110	= 0.87
25	= 0.495	70	= 0.715	115	= 0.885
30	= 0.525	75	= 0.735	120	= 0.9
35	= 0.55	80	= 0.755	125	= 0.92
40	= 0.575	85	= 0.775	130	= 0.935
45	= 0.6	90	= 0.795	135	= 0.95
50	= 0.625	95	= 0.815	140	= 0.965
55	= 0.65	100	= 0.835	145	= 0.98
60	= 0.675	105	= 0.85	150	= 1.000

TABLE 2. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 12 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	241	362	482	602	723	843	964	1084	1205	1325	1446	1566	1687	1807	1928	2048	2169	2289	2410
25	260	390	520	650	780	910	1040	1170	1300	1430	1560	1690	1820	1950	2080	2210	2340	2470	2600
30	275	412	550	687	825	962	1100	1237	1375	1512	1650	1787	1925	2062	2200	2337	2475	2612	2750
35	288	432	576	720	864	1008	1152	1296	1440	1584	1728	1872	2016	2160	2304	2448	2592	2736	2880
40	301	451	602	752	903	1053	1204	1354	1505	1655	1806	1956	2107	2257	2408	2558	2709	2859	3010
45	315	472	630	787	945	1102	1260	1417	1575	1732	1890	2047	2205	2362	2520	2677	2835	2992	3150
50	328	492	656	820	984	1148	1312	1476	1640	1804	1968	2132	2296	2460	2624	2788	2952	3116	3280
55	341	511	682	852	1023	1193	1364	1534	1705	1875	2046	2216	2387	2557	2728	2898	3069	3239	3410
60	354	531	708	885	1062	1239	1416	1593	1770	1947	2124	2301	2478	2655	2832	3009	3186	3363	3540
65	364	546	728	910	1092	1274	1456	1638	1820	2002	2184	2366	2548	2730	2912	3094	3276	3458	3640
70	375	562	750	937	1125	1312	1500	1687	1875	2062	2250	2437	2625	2812	3000	3187	3375	3562	3750
75	385	577	770	962	1155	1347	1540	1732	1925	2117	2310	2502	2695	2887	3080	3272	3465	3657	3850
80	396	594	792	990	1188	1386	1584	1782	1980	2178	2376	2574	2772	2970	3168	3366	3564	3762	3960
85	406	609	812	1015	1218	1421	1624	1827	2030	2233	2436	2639	2842	3045	3248	3451	3654	3857	4060
90	417	625	834	1042	1251	1459	1668	1876	2085	2293	2502	2710	2919	3127	3336	3544	3753	3961	4170
95	427	640	854	1067	1281	1494	1708	1921	2135	2348	2562	2775	2989	3202	3416	3629	3843	4056	4270
100	438	657	876	1095	1314	1533	1752	1971	2190	2409	2628	2847	3066	3285	3504	3723	3942	4161	4380
105	446	669	892	1115	1338	1561	1784	2007	2230	2453	2676	2899	3122	3345	3568	3791	4014	4237	4460
110	456	684	912	1140	1368	1596	1824	2052	2280	2508	2736	2964	3192	3420	3648	3876	4104	4332	4560
115	464	696	928	1160	1392	1624	1856	2088	2320	2552	2784	3016	3248	3480	3712	3944	4176	4408	4640
120	472	708	944	1180	1416	1652	1888	2124	2360	2596	2832	3068	3304	3540	3776	4012	4248	4484	4720
125	483	724	966	1207	1449	1690	1932	2173	2415	2656	2898	3139	3381	3622	3864	4105	4347	4588	4830
130	490	735	980	1225	1470	1715	1960	2205	2450	2695	2940	3185	3430	3675	3920	4165	4410	4655	4900
135	498	747	996	1245	1494	1743	1992	2241	2490	2739	2988	3237	3486	3735	3984	4233	4482	4731	4980
140	506	759	1012	1265	1518	1771	2024	2277	2530	2783	3036	3289	3542	3795	4048	4301	4554	4807	5060
145	514	771	1028	1285	1542	1799	2056	2313	2570	2827	3084	3341	3598	3855	4112	4369	4626	4883	5140
150	525	787	1050	1312	1575	1837	2100	2362	2625	2887	3150	3412	3675	3937	4200	4462	4725	4987	5250

TABLE 3. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 10 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	161	241	322	402	483	563	644	724	805	885	966	1046	1127	1207	1288	1368	1449	1529	1610
25	173	259	346	432	519	605	692	778	865	951	1038	1124	1211	1297	1384	1470	1557	1643	1730
30	183	274	366	457	549	640	732	823	915	1006	1098	1189	1281	1372	1464	1555	1647	1738	1830
35	192	288	384	480	576	672	768	864	960	1056	1152	1248	1344	1440	1536	1632	1728	1824	1920
40	201	301	402	502	603	703	804	904	1005	1105	1206	1306	1407	1507	1608	1708	1809	1909	2010
45	210	315	420	525	630	735	840	945	1050	1155	1260	1365	1470	1575	1680	1785	1890	1995	2100
50	218	327	436	545	654	763	872	981	1090	1199	1308	1417	1526	1635	1744	1853	1962	2071	2180
55	227	340	454	567	681	794	908	1021	1135	1248	1362	1475	1589	1702	1816	1929	2043	2156	2270
60	236	354	472	590	708	826	944	1062	1180	1298	1416	1534	1652	1770	1888	2006	2124	2242	2360
65	243	364	486	607	729	850	972	1093	1215	1336	1458	1579	1701	1822	1944	2065	2187	2308	2430
70	250	375	500	625	750	875	1000	1125	1250	1375	1500	1625	1750	1875	2000	2125	2250	2375	2500
75	257	385	514	642	771	899	1028	1156	1285	1413	1542	1670	1799	1927	2056	2184	2313	2461	2570
80	264	396	528	660	792	924	1056	1188	1320	1452	1584	1716	1848	1980	2112	2244	2376	2508	2640
85	271	406	542	677	813	948	1084	1219	1355	1490	1626	1761	1897	2032	2168	2303	2439	2574	2710
90	278	417	556	695	834	973	1112	1251	1390	1529	1668	1807	1946	2085	2224	2363	2502	2641	2780
95	285	427	570	712	855	997	1140	1282	1425	1567	1710	1852	1995	2137	2280	2422	2565	2707	2850
100	292	438	584	730	876	1022	1168	1314	1460	1606	1752	1898	2044	2190	2336	2482	2628	2774	2920
105	297	445	594	742	891	1039	1188	1336	1485	1633	1782	1930	2079	2227	2376	2524	2673	2821	2970
110	304	456	608	760	912	1064	1216	1368	1520	1672	1824	1976	2128	2280	2432	2584	2736	2888	3040
115	309	463	618	772	927	1081	1236	1390	1545	1699	1854	2008	2163	2317	2472	2626	2781	2935	3090
120	315	472	630	787	945	1102	1260	1417	1575	1732	1890	2047	2205	2362	2520	2677	2835	2992	3150
125	322	483	644	805	966	1127	1288	1449	1610	1771	1932	2093	2254	2415	2576	2737	2898	3059	3220
130	327	490	654	817	981	1144	1308	1471	1635	1798	1962	2125	2289	2452	2616	2779	2943	3106	3270
135	332	498	664	830	996	1162	1328	1494	1660	1826	1992	2158	2324	2490	2656	2822	2988	3154	3320
140	337	505	674	842	1011	1179	1348	1516	1685	1853	2022	2190	2359	2527	2696	2864	3033	3201	3370
145	343	514	686	857	1029	1200	1372	1543	1715	1886	2058	2229	2401	2572	2744	2915	3087	3258	3430
150	350	525	700	875	1050	1225	1400	1575	1750	1925	2100	2275	2450	2625	2800	2975	3150	3325	3500

TABLE 4. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 8 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	95	142	190	237	285	332	380	427	475	522	570	617	665	712	760	807	855	902	950
25	102	153	204	255	306	357	408	459	510	561	612	663	714	765	816	867	918	969	1020
30	108	162	216	270	324	378	432	486	540	594	648	702	756	810	864	918	972	1026	1080
35	113	169	226	282	339	395	452	508	565	621	678	734	791	847	904	960	1017	1073	1130
40	118	177	236	295	354	413	472	531	590	649	708	767	826	885	944	1003	1062	1121	1180
45	124	186	248	310	372	434	496	558	620	682	744	806	868	930	992	1054	1116	1178	1240
50	129	193	258	322	387	451	516	580	645	709	774	838	903	967	1032	1096	1161	1225	1290
55	134	201	268	335	402	469	536	603	670	737	804	871	938	1005	1072	1139	1206	1273	1340
60	139	208	278	347	417	486	556	625	695	764	834	903	973	1042	1112	1181	1251	1320	1390
65	143	214	286	357	429	500	572	643	715	786	858	929	1001	1072	1144	1215	1287	1358	1430
70	147	220	294	367	441	514	588	661	735	808	882	955	1029	1102	1176	1249	1323	1396	1470
75	151	226	302	377	453	528	604	679	755	830	906	981	1057	1132	1208	1283	1359	1434	1510
80	156	234	312	390	468	546	624	702	780	858	936	1014	1092	1170	1248	1326	1404	1482	1560
85	160	240	320	400	480	560	640	720	800	880	960	1040	1120	1200	1280	1360	1440	1520	1600
90	164	246	328	410	492	574	656	738	820	902	984	1066	1148	1230	1312	1394	1476	1558	1640
95	168	252	336	420	504	588	672	756	840	924	1008	1092	1176	1260	1344	1428	1512	1596	1680
100	172	258	344	430	516	602	688	774	860	946	1032	1118	1204	1290	1376	1462	1548	1634	1720
105	175	262	350	437	525	612	700	787	875	962	1050	1137	1225	1312	1400	1487	1575	1662	1750
110	179	268	358	447	537	626	716	805	895	984	1074	1163	1253	1342	1432	1521	1611	1700	1790
115	182	273	364	455	546	637	728	819	910	1001	1092	1183	1274	1365	1456	1547	1638	1729	1820
120	186	279	372	465	558	651	744	837	930	1023	1116	1209	1302	1395	1488	1581	1674	1767	1860
125	190	285	380	475	570	665	760	855	950	1045	1140	1235	1330	1425	1520	1615	1710	1805	1900
130	193	289	386	482	579	675	772	868	965	1061	1158	1254	1351	1447	1544	1640	1737	1833	1930
135	196	294	392	490	588	686	784	882	980	1078	1176	1274	1372	1470	1568	1666	1764	1862	1960
140	199	298	398	497	597	696	796	895	995	1094	1194	1293	1393	1492	1592	1691	1791	1890	1990
145	202	303	404	505	606	707	808	909	1010	1111	1212	1313	1414	1515	1616	1717	1818	1919	2020
150	206	309	412	515	618	721	824	927	1030	1133	1236	1339	1442	1545	1648	1751	1854	1957	2060

With these constants table No. 1 is figured. This table gives the horsepower for the given pipe sizes and steam pressures for a reading of 1 on the meter chart. When using this table, multiply the chart reading by the constant corresponding to the pipe sizes and gage pressure. Then correct for moisture or superheat. If another inner mechanism than a No. 6 is used, correct for that, as already stated.

The integrating attachment to one of these meters does away with the necessity of calculating the steam flow at stated periods and averaging the result, or adding them to get the total. The device gives the total chart reading, which is multiplied by the result of the calculations given with Diagram No. 11.

With the integrating device the following formula is given for Type F meter with nozzle plug:

$$\text{Total flow in lb.} = \frac{\text{net dial reading} \times 4.7 \times K_1 \times K_2 \times K_3 \times K_4 \times K_{cp}}{\text{revolutions of chart in 24 hr.}}$$

TABLE 5. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 6 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	53	79	106	132	159	185	212	238	265	291	318	344	371	397	424	450	477	503	530
25	57	85	114	142	171	199	228	256	285	313	342	370	399	427	456	484	513	541	570
30	61	91	122	152	183	213	244	274	305	335	366	396	427	457	488	518	549	579	610
35	64	96	128	160	192	224	256	288	320	352	384	416	448	480	512	544	576	608	640
40	67	100	134	167	201	234	268	301	335	368	402	435	469	502	536	569	603	636	670
45	70	105	140	175	210	245	280	315	350	385	420	455	490	525	560	595	630	665	700
50	72	108	144	180	216	252	288	324	360	396	432	468	504	540	576	612	648	684	720
55	75	112	150	187	225	262	300	337	375	412	450	487	525	562	600	637	675	712	750
60	78	117	156	195	234	273	312	351	390	429	468	507	546	585	624	663	702	741	780
65	81	121	162	202	243	283	324	364	405	445	486	526	567	607	648	688	729	769	810
70	83	124	166	207	249	290	332	373	415	456	498	539	581	622	664	705	747	788	830
75	85	127	170	212	255	297	340	382	425	467	510	552	595	637	680	722	765	807	850
80	88	132	176	220	264	308	352	396	440	484	528	572	616	660	704	748	792	836	880
85	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	765	810	855	900
90	92	138	184	230	276	322	368	414	460	506	552	598	644	690	736	782	828	874	920
95	95	142	190	237	285	332	380	427	475	522	570	617	665	712	760	807	855	902	950
100	97	145	194	242	291	339	388	436	485	533	582	630	679	727	776	824	873	921	970
105	99	148	198	247	297	346	396	445	495	544	594	643	693	742	792	841	891	940	990
110	101	151	202	252	303	353	404	454	505	555	606	656	707	757	808	858	909	959	1010
115	103	154	206	257	309	360	412	463	515	566	618	669	721	772	824	875	927	978	1030
120	105	157	210	262	315	367	420	472	525	577	630	682	735	787	840	892	945	997	1050
125	107	160	214	267	321	374	428	481	535	588	642	695	749	802	856	909	963	1016	1070
130	109	163	218	272	327	381	436	490	545	599	654	708	763	817	872	926	981	1035	1090
135	110	165	220	275	330	385	440	495	550	605	660	715	770	825	880	935	990	1045	1100
140	112	168	224	280	336	392	448	504	560	616	672	728	784	840	896	952	1008	1064	1120
145	114	171	228	285	342	399	456	513	570	627	684	741	798	855	912	969	1026	1083	1140
150	116	174	232	290	348	406	464	522	580	638	696	754	812	870	928	986	1044	1102	1160

TABLE 6. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 4 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	21	31	42	52	63	73	84	94	105	115	126	136	147	157	168	178	189	199	210
25	23	34	46	57	69	80	92	103	115	126	138	149	161	172	184	195	207	218	230
30	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240
35	25	37	50	62	75	87	100	112	125	137	150	162	175	187	200	212	225	237	250
40	26	39	52	65	78	91	104	117	130	143	156	169	182	195	208	221	234	247	260
45	28	42	56	70	84	98	112	126	140	154	168	182	196	210	224	238	252	266	280
50	29	43	58	72	87	101	116	130	145	159	174	188	203	217	232	246	261	275	290
55	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300
60	31	46	62	77	93	108	124	139	155	170	186	201	217	232	248	263	279	294	310
65	32	48	64	80	96	112	128	144	160	176	192	208	224	240	256	272	288	304	320
70	33	49	66	82	99	115	132	148	165	181	198	214	231	247	264	280	297	313	330
75	34	51	68	85	102	119	136	153	170	187	204	221	238	255	272	289	306	323	340
80	35	52	70	87	105	122	140	157	175	192	210	227	245	262	280	297	315	332	350
85	36	54	72	90	108	126	144	162	180	198	216	234	252	270	288	306	324	342	360
90	37	55	74	92	111	129	148	166	185	203	222	240	259	277	296	314	333	351	370
95	38	57	76	95	114	133	152	171	190	209	228	247	266	285	304	323	342	361	380
100	38.9	58.3	77.8	97.2	116.7	136.1	155.6	175	194.5	213.9	233.4	252.8	272.3	291.7	311.2	330.6	350.1	369.5	389
105	39.6	59.4	79.2	99	118.8	138.6	158.4	178.2	198	217.8	237.6	257.4	277.2	297	316.8	336.6	356.4	376.2	396
110	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400
115	41	61	82	102	123	143	164	184	205	225	246	266	287	307	328	348	369	389	410
120	42	63	84	105	126	147	168	189	210	231	252	273	294	315	336	357	378	399	420
125	42.8	64.2	85.6	107	128.4	149.8	171.2	192.6	214	235.4	256.8	278.2	299.6	321	342.4	363.8	385.2	406.6	428
130	43.6	65.4	87.2	109	130.8	152.6	174.4	196.2	218	239.8	261.6	283.4	305.2	327	348.8	370.6	392.4	414.2	436
135	44.3	66.4	88.6	110.7	132.9	155	177.2	199.3	221.5	243.6	265.8	287.9	310.1	332.2	354.4	376.5	398.7	420.8	443
140	45	67	90	112	135	157	180	202	225	247	270	292	315	337	360	382	405	427	450
145	45.7	68.5	91.4	114.2	137.1	159.9	182.8	205.6	228.5	251.3	274.2	297	319.9	342.7	365.6	388.4	411.3	434.1	457
150	46.6	69.9	93.2	116.5	139.8	163.1	186.4	209.7	233	256.3	279.6	302.9	326.2	349.5	372.8	396.1	419.4	442.7	466

TABLE 7. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 3 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	12.2	18.3	24.4	30.5	36.6	42.7	48.8	54.9	61	67.1	73.2	79.3	85.4	91.5	97.6	103.7	109.8	115.9	122
25	13.2	19.8	26.4	33	39.6	46.2	52.8	59.4	66	72.6	79.2	85.8	92.4	99	105.6	112.2	118.8	125.4	132
30	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140
35	14.6	21.9	29.2	36.5	43.8	51.1	58.4	65.7	73	80.3	87.6	94.9	102.2	109.5	116.8	124.1	131.4	138.7	146
40	15.3	22.9	30.6	38.2	45.9	53.5	61.2	68.8	76.5	84.1	91.8	99.4	107.1	114.7	122.4	130	137.7	145.3	153
45	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144	152	160
50	16.6	24.9	33.2	41.5	49.8	58.1	66.4	74.7	83	91.3	99.6	107.9	116.2	124.5	132.8	141.1	149.4	157.7	166
55	17.3	25.9	34.6	43.2	51.9	60.5	69.2	77.8	86.5	95.1	103.8	112.4	121.1	129.7	138.4	147	155.7	164.3	173
60	18	27	36	45	54	63	72	81	90	99	108	117	126	135	144	153	162	171	180
65	18.5	27.7	37	46.2	55.5	64.7	74	83.2	92.5	101.7	111	120.2	129.5	138.7	148	157.2	166.5	175.7	185
70	19	28.5	38	47.5	57	66.5	76	85.5	95	104.5	114	123.5	133	142.5	152	161.5	171	180.5	190
75	19.6	29.4	39.2	49	58.8	68.6	78.4	88.2	98	107.8	117.6	127.4	137.2	147	156.8	166.6	176.4	186.2	196
80	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
85	20.6	30.9	41.2	51.5	61.8	72.1	82.4	92.7	103	113.3	123.6	133.9	144.2	154.5	164.8	175.1	185.4	195.7	206
90	21.2	31.8	42.4	53	63.6	74.2	84.8	95.4	106	116.6	127.2	137.8	148.4	159	169.6	180.2	190.8	201.4	212
95	21.7	32.5	43.4	54.2	65.1	75.9	86.8	97.6	108.5	119.3	130.2	141	151.9	162.7	173.6	184.4	195.3	206.1	217
100	22.2	33.3	44.4	55.5	66.6	77.7	88.8	99.9	111	122.1	133.2	144.3	155.4	166.5	177.6	188.7	199.8	210.9	222
105	22.6	33.9	45.2	56.5	67.8	79.1	90.4	101.7	113	124.3	135.6	146.9	158.2	169.5	180.8	192.1	203.4	214.7	226
110	23.2	34.8	46.4	58	69.6	81.2	92.8	104.4	116	127.6	139.2	150.8	162.4	174	185.6	197.2	208.8	220.4	232
115	23.6	35.4	47.2	59	70.8	82.6	94.4	106.2	118	129.8	141.6	153.4	165.2	177	188.8	200.6	212.4	224.2	236
120	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240
125	24.5	36.7	49	61.2	73.5	85.7	98	110.2	122.5	134.7	147	159.2	171.5	183.7	196	208.2	220.5	232.7	245
130	24.9	37.3	49.8	62.2	74.7	87.1	99.6	112	124.5	136.9	149.4	161.8	174.3	186.7	199.2	211.6	224.1	236.5	249
135	25.3	37.9	50.6	63.2	75.9	88.5	101.2	113.8	126.5	139.1	151.8	164.4	177.1	189.7	202.4	215	227.7	240.3	253
140	25.7	38.5	51.4	64.2	77.1	89.9	102.8	115.6	128.5	141.3	154.2	167	179.9	192.7	205.6	218.4	231.3	244.1	257
145	26.1	39.1	52.2	65.2	78.3	91.3	104.4	117.4	130.5	143.5	156.6	169.6	182.7	195.7	208.8	221.8	234.9	247.9	261
150	26.6	39.9	53.2	66.5	79.8	93.1	106.4	119.7	133	146.3	159.6	172.9	186.2	199.5	212.8	226.1	239.4	252.7	266

The numeral 4.7 stands for the integrating dial constant which is given on the nameplate.

To use these tables the formula is as follows:

$$\text{Total horsepower} = \frac{\text{net dial reading} \times \text{constant} \times \text{horsepower from Table 1}}{\text{revolutions of chart in 24 hr.}}$$

To change to number of pounds of steam, multiply the above by 30.

If other than No. 6 inner mechanism is used, multiply the above by the constant given in Diagram 11 for the proper mechanism.

Correct for moisture or superheat.

For example, let us assume the following: The steam-pipe diameter is 12 in.; the average steam pressure at 100 lb. equals 438 hp. (Table 1); the integrating-dial reading for 24 hr. is 30; the dial constant is 4.7; and the reading of the meter chart in revolutions is 1. Then

$$\frac{30 \times 4.7 \times 438}{1} = 61{,}758 \text{ total horsepower}$$

Where the integrating device is not in use, the Tables 2, 3, 4, 5, 6 and 7 are of especial use. With these the horsepower for any chart reading and given pressure can be read direct; each table is for a given pipe size.

Converter Station of Aluminum Company of America

SYNOPSIS—The equipment includes nine 2500-kw. rotary converters, outdoor transformers and high-tension switches and special control and protective apparatus.

The installation of nine 2500-kw. 60-cycle rotary converters at the Little Tennessee Plant of the Aluminum Company of America at Maryville, Tenn., in addition to constituting one of the largest 60-cycle rotary-converter installations in the world, presents a number of interesting features in the arrangement of the controlling and protective equipment. Energy is brought to the station by the Tennessee Power Co. over a single-circuit transmission line 70 miles in length, consisting of 400,000-circ.mil stranded aluminum cables, carried on steel towers 55 ft. in height, the lines being hung from suspension insulators. Temporarily, a transmission voltage of 66,000 is used, which later will be boosted to 110,000 volts.

Two banks of three 3650-kv.-a. 110,000/66,000-volt outdoor-type single-phase transformers are used to step down to the converter voltage, four six-phase machines

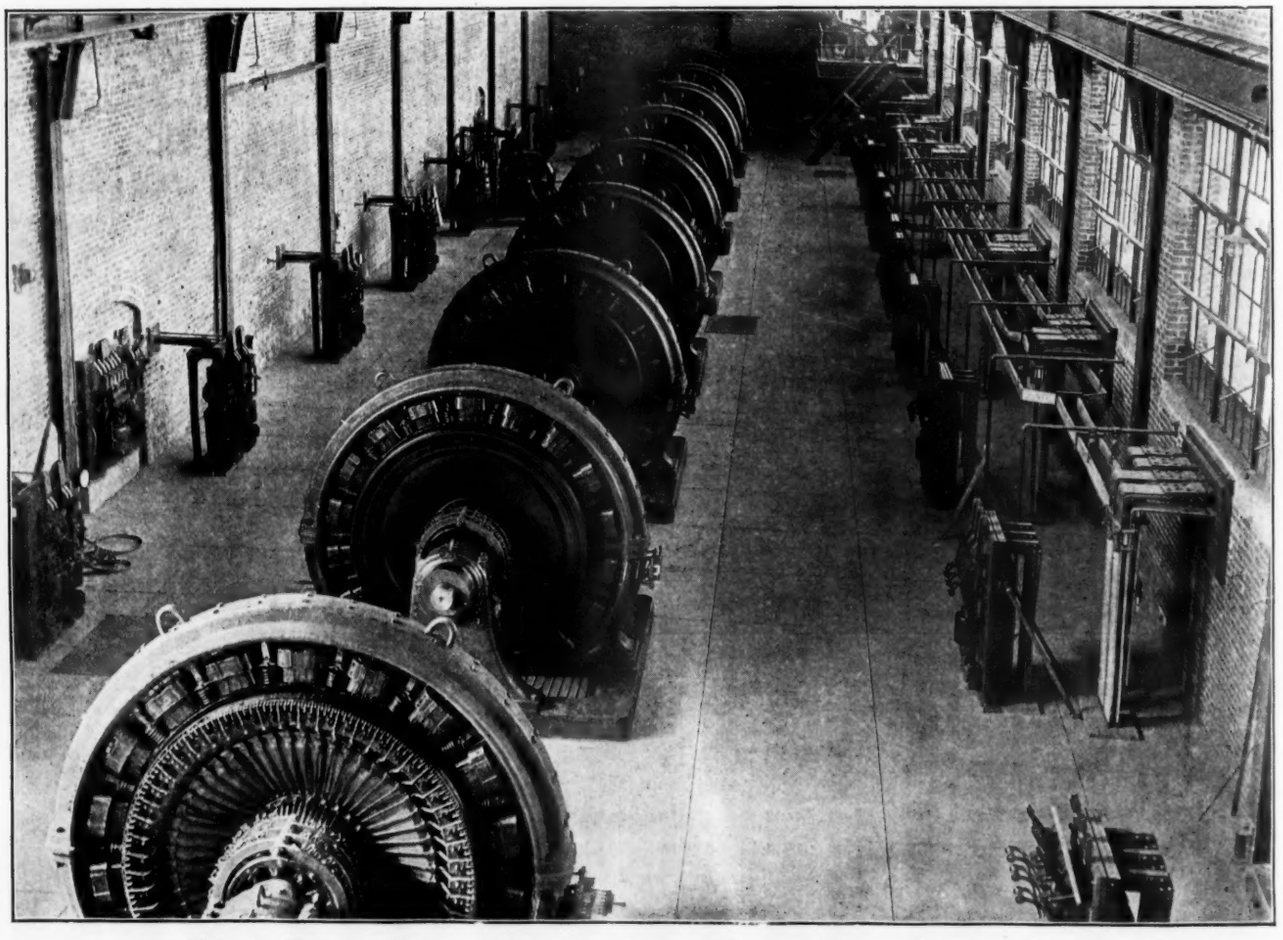


FIG. 1. INTERIOR VIEW OF STATION, SHOWING CONVERTERS AND CONTROL PANELS

operating from independent secondaries on each bank, with provision for operating one spare unit from any set of secondaries of either bank. Automatic overload protection is provided by three-pole outdoor oil circuit-breakers equipped with outdoor condenser-type terminals and ring-type current transformers. The breakers are solenoid operated, and are controlled from the control desk located in the station. The breakers are isolated from the transmission line by means of three-pole outdoor disconnecting switches which are mechanically controlled by a handle installed in the station. One of these switches is shown in Fig. 2 between the supports of the transmission tower. The outdoor lightning arrester of the electrolytic type, shown at the left, provides protection against lightning.

The low-tension leads from the transformers are carried directly through the station wall and the six-phase connections are made beneath the floor. The aluminum-strap bus arrangement shown along the right-hand station wall in Fig. 1 provides the necessary connections for transferring the spare converter to any set of secondaries of either bank of step-down transformers.

The converters are ordinarily started from the 500-volt direct-current side, although two are arranged so that alternating-current starting motors may be used. Owing to the size of the machines and their large overload capacity, the switching equipment for both the alternating- and the direct-current ends is somewhat unusual in character. For the control of the alternating-current ends of the converters, 2500-amp., three-pole, solenoid-operated automatic carbon circuit-breakers are used, and for the direct-current ends the control consists of two 5000-amp., single-pole, solenoid-operated automatic carbon circuit-breakers for each machine. The alternating- and the direct-current panels are located adjacent to each machine, thus reducing to a minimum the length of the main connections. Low-voltage protection is provided on the alternating-current panels, and protection against reversal of direct current is secured by reverse-current relays.

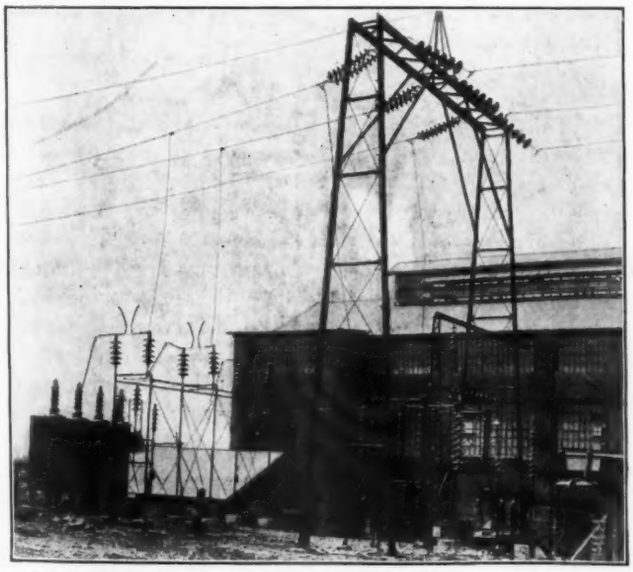


FIG. 2. OUTDOOR SWITCHES AND LIGHTNING ARRESTERS

The output of the converters, which is used in the manufacture of aluminum, is distributed through a 20,000-amp. single-pole solenoid-operated automatic carbon circuit-breaker, and two 10,000-amp. single-pole solenoid-operated automatic carbon circuit-breakers, mounted directly against the left-hand wall; see Fig. 1. The panels for the control of the direct-current ends are also on this side.

The details of the brush construction of the 20,000-amp. breaker are shown in Fig. 3. The main brush consists of six unit brushes of laminated copper so spaced as to secure the benefit of maximum ventilating effect.

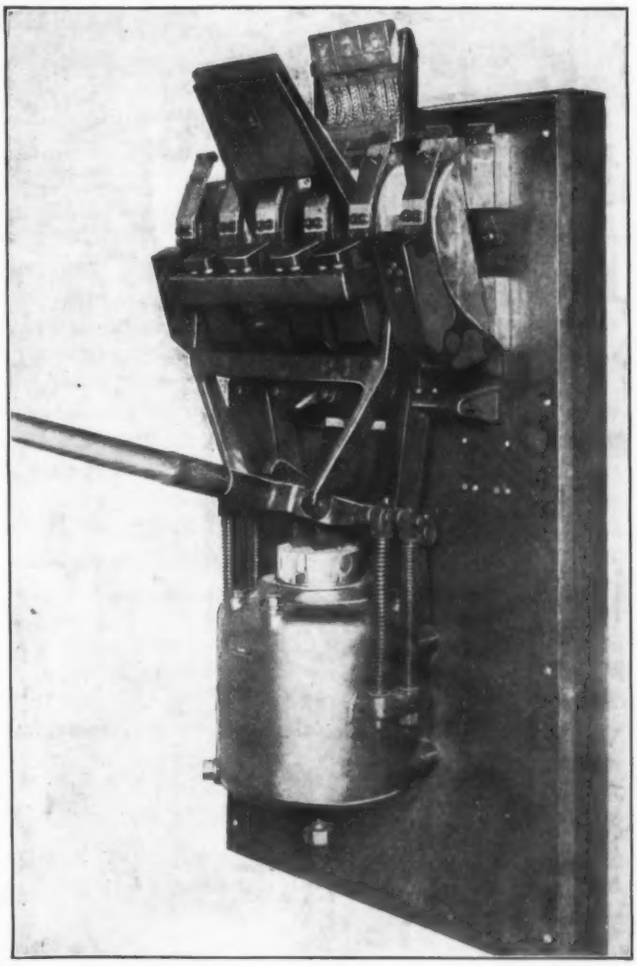


FIG. 3. 20,000-AMP. CIRCUIT-BREAKER

Auxiliary arc-interrupting contacts are located above the main brush and on the lower portion of the carbon contacts, which make the final break. Laminated studs are used for all breakers, and a single solenoid is used for operating each breaker, regardless of the number of poles, making possible a very simple and direct-acting operating mechanism.

The metering and controlling equipment for the alternating- and the direct-current sides of the converters, as well as for the high-tension side of the step-down transformers, is installed upon the control desk located in the balcony.

Current for operating the solenoids of the switching equipment and for the station lighting is provided by a motor-generator set consisting of a 60-kv.-a., 125-250 volt, three-phase generator driven by a 500-volt direct-current motor.

The electrical equipment for the station was manufactured by the Westinghouse Electric & Manufacturing Co. under the direction of William Hoopes, electrical engineer of the Aluminum Company of America.

Inconspicuous Losses in Refrigerating Plants

By Peter Neff

SYNOPSIS—You can see steam leaks and smell ammonia leaks, but you can neither see nor smell those heat losses by transmission through the walls that confine the heat units. The article suggests how these leaks may mean considerable loss in a short time.

Anyone can see a steam leak or smell an ammonia leak and know that a loss is going on, but many are often unaware of those silent, unnoticeable losses that go on continually, due to heat transmission, and while these cannot be entirely prevented, they can and should be minimized.

A plant may have good cold water and an efficient ammonia condenser, making it possible to get the liquid ammonia away from the condenser at, we will say, a temperature of 60 deg. Then this ammonia is conveyed through pipes to a receiver, perhaps located in a hot engine room, with the result that the ammonia goes to the feed valve possibly nearer 80 than 60 deg.

What do these 20 deg. mean? Suppose the plant is of 100 tons' refrigerating capacity and is circulating about 40 lb. of ammonia per minute, these 20 deg. mean about 800 heat units per minute unnecessarily added to the load. Two hundred heat units per minute is equivalent to a ton of refrigeration per day, so that this loss amounts to approximately four tons of refrigeration per day. It may be argued that this is not much in a 100-ton plant. But the loss represents money. The greater part might be saved by spending a few dollars on insulation, at least covering the receiver.

See that the ammonia leaves the condenser at as near as possible the temperature of the water available and that it does not rise in temperature before reaching the feed valves.

This brings up the question of the use of thermometers about a refrigerating plant, a subject the writer will take up at some future time. Suffice it for now to say, one might as well try to run an electric plant efficiently without voltmeters or ammeters as to attempt to operate a refrigerating plant without thermometers.

The suction line leading to the compressor is much neglected; sometimes it bears evidence of an attempt at insulation, but the last state is often worse than the first. Most engineers know of the loss due to the exposed steam piping, but frequently do not apply this knowledge to the suction line.

To relate an instance of how this matter is sometimes viewed, the writer found in a plant, a 4-in. ammonia suction line running partly in close proximity to steam condensers and thence through the hottest part of the engine room before reaching the compressor; obviously this line had been put there intentionally. Upon inquiry, this statement was given in answer: "You heat the gas in the compressor, therefore it is desirable to heat it as much as possible beforehand and save work by the machine." An hour was spent in a vain attempt to convince the operator of his error, but he had only pity for me and my ignorence. Happily, such instances are rare.

Suppose the suction line offers 100 sq.ft. of exposed surface, and assume a heat transmission of 10 units per hour per degree difference. It is no uncommon thing to find the suction line exposed to a room temperature of 80 deg., while the ammonia gas leaving the place of evaporation is at zero.

We may fairly assume an average difference of 60 deg., or 60,000 heat units per hour, which is equivalent to five tons of refrigeration per day. This is not all, for while the refrigeration load has been increased, the capacity of the compressor has been cut down.

It is well known that refrigeration is accomplished primarily by the heat absorbed in changing the liquid ammonia into a gas and that this gas is at first in what is termed a saturated condition where a given volume has a maximum weight. It is also well known that if this gas be heated it will expand and the weight in a given volume will be reduced. As the compressor offers a constant volume for the reception of the gas, it follows that the greater the density of the gas, the greater will be the weight handled by the compressor. So it is obvious that it is desirable to get the gas to the compressor without superheating it.

We have supposed that superheating of the gas has taken place, owing to the exposed suction line, so that in reality there has been an attempt to cool the engine room or outdoors, wherever the suction line has been run, which was neither desired nor intended, but which has required an expenditure of energy that represents a money loss.

In the supposed case the 40 lb. of ammonia per minute, when in the form of a saturated gas at zero degrees, occupied approximately 367 cu.ft. If, now, this gas is raised in temperature to only 50 deg., we find that the gas that had formerly occupied the space of 367 cu.ft. will now occupy 416 cu.ft. If the compressor is to handle the same weight of ammonia, which it must do to produce the same amount of refrigeration, its speed must be increased 13½ per cent.

The plant may be, as far as visible observation can tell, working well, everything apparently in perfect order, not a leak of steam or ammonia and yet there may be some such losses going on.

While, perhaps, the increased number of revolutions does not, owing to the friction load, increase the horsepower proportionately, it nearly does so, and almost any engineer may calculate what this loss means in fuel cost.

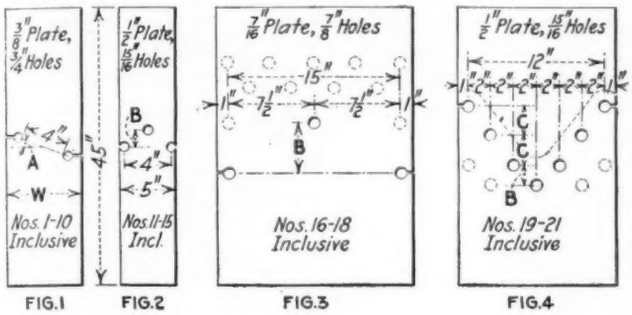
The engineer who wants to build up a reputation and to make himself valuable to the concern which employs him will, in addition to keeping his plant free from those defects that are obvious to anyone, be on the lookout for those losses not apparent on the surface. It is this care that makes some men so much more successful than others.

There are many other losses going on, but the examples given illustrate the importance of looking into the heat-transmission losses.

Tests on the Diagonal Strength of Boiler Plate

By J. W. F. Macdonald*

On Apr. 10 tensile tests were conducted at the Watertown (Mass.) Arsenal on 21 specimens of boiler plate. The object of the tests was to determine the minimum distance between rows at which the joint fails through the net section along the line of rivets in one row, rather than along the zigzag diagonal lines. The test specimens



Specimens on Which Tests Were Made

were prepared by the International Engineering Works, Ltd., Framingham, Mass., from material furnished by the Lukens Iron & Steel Co., Coatesville, Penn. Following is the mill test report for the steel used:

Slab No.	9968 G	9968 J	9968 H
Physical properties—			
Width, in.	1.725	1.915	1.816
Thickness, in.	0.380	0.447	0.515
Area, sq.in.	0.655	0.856	0.935
Elastic limit—			
Lb. per sq.in.	36,660	38,090	36,160
Tensile strength—			
Lb. per sq.in.	59,680	59,340	57,760
Elongation—			
Per cent. in 8 in.	30.0	28.0	29.5
Reduction in area, per cent.	60.3	60.7	57.2
Chemical properties, per cent.—			
Carbon	0.17	0.17	0.18
Manganese	0.36	0.36	0.44
Sulphur	0.023	0.023	0.030
Phosphorus	0.018	0.018	0.012

The first ten specimens had a section 4 in. wide and 3/8 in. thick between hole centers. The lines through this section were placed at an angle *A* (see Fig. 1) to the line normal to stress, varying from 0 to 90 deg. in 10-deg. increments. The purpose of this series of ten was to obtain data for a curve giving the strength of the material for the different angles. From this curve the proportion of metal necessary along the diagonal lines could be found directly.

Specimens Nos. 11 to 21 inclusive were arranged with varying proportions between the net amount of material along the diagonal lines and that straight across between the two holes in the same line. Nos. 11, 12, 13, 14 and 15 (Fig. 2) had a 4-in. pitch and represented typical spacing in the inner rows of riveted joints. Nos. 16, 17 and 18 (Fig. 3) represented the rivet holes in the two outer rows of the ordinary type of quadruple butt joint with an outer pitch of 15 inches. In No. 16 there is actually less material along the diagonal lines between the two outer rows than there is directly between rivets in the outer row, a condition given no consideration in the rules for calculating such joints. Nos. 19, 20 and 21 (Fig. 4) represented the rivet holes inside the calking edge of the sawtooth type of quadruple butt joint with an outer pitch of 12 inches.

Where the same thickness of plate was used, test specimens were all cut from the same slab, in order to have conditions as uniform as possible. The actual results in the first ten specimens show remarkable uniformity, particularly with reference to the elastic limit indicated by the first scaling of the plate and drop of the beam. The results of tests made on these specimens follow:

No.	Angle A (See Fig. 1), Deg.	Width (W) Specimen, In.	Section Between Holes, Sq.In.	Elastic Limit in Lb. Total	Elastic Limit in Lb. Per Sq.In.	Ultimate Strength in Lb. Total	Ultimate Strength in Lb. Per Sq.In.	Relative Ultimate Strength Per Cent.
1	0	7	1.52	62,200	40,900	96,400	63,400	100
2	10	7	1.56	57,100	36,600	92,700	59,400	93.6
3	20	7	1.52	51,100	33,600	87,400	57,500	90.7
4	30	7	1.52	45,000	29,600	81,000	53,300	84.0
5	40	8	1.56	40,500	26,000	78,100	50,100	79.0
6	50	9	1.56	37,500	24,000	74,900	48,000	75.7
7	60	10	1.56	32,800	21,000	71,000	45,500	71.7
8	70	10	1.56	29,200	18,800	70,500	45,200	71.2
9	80	11	1.52	27,900	18,400	71,900	47,300	74.6
10	90	11	1.52	26,900	17,700	63,100	41,500	65.5

Curves Nos. 1 and 2 were plotted with the ultimate strength and elastic limits as ordinates and different angles as abscissas. These curves show that the ultimate strength decreased almost uniformly with the increased angle from direct tension to direct shear.

Specimen No. 11, in which the areas diagonally and straight across were equal, and No. 16, in which the latter was slightly greater, failed diagonally through the three holes, as was expected. Specimen No. 13 was stronger than would be indicated from the results found in the first ten specimens, the ultimate failure being straight across. With a riveted connection, where the holes were forced to retain their full width and the metal was prevented from flowing to the extent it did, as shown by the elongation of the holes along the line of stress and their contraction transversely, the results would probably

Results of Tests on Specimens Nos. 11 to 21 Inclusive

No.	Section Normal to Stress Width, In.	Section Normal to Stress Thickness, In.	Section Normal to Stress Area, Sq.In.	Diagonal Length, In.	Diagonal Section Area, Sq.In.	Diagonal in Per Cent. of Normal Section	Back Pitch (See Figs. 2-4) B In.	Back Pitch (See Figs. 2-4) C In.	Elastic Limit in Lb. Total	Elastic Limit in Lb. Per Sq.In.	Ultimate Strength in Lb. Total	Ultimate Strength in Lb. Per Sq.In.	Efficiency of Section in Per Cent. Theoretical	Efficiency of Section in Per Cent. Actual
11	3.06	0.52	1.59	3.06	1.59	100	1.45	...	44,000	27,700	91,000	57,200	76.5	75.7
12	3.06	0.52	1.59	3.44	1.79	113	1.75	...	44,200	27,800	94,500	59,400	76.5	78.6
13	3.06	0.52	1.59	3.68	1.91	120	1.93	...	48,000	30,200	96,400	60,600	76.5	80.2
14	3.06	0.52	1.59	4.08	2.12	133	2.21	...	50,000	31,400	101,000	63,500	76.5	84.0
15	3.06	0.51	1.56	4.58	2.34	150	2.54	...	51,700	33,100	98,600	63,200	76.5	83.6
16	14.12	0.45	6.35	13.91	6.26	98	2.25	...	204,000	32,600	324,600	51,900	94.1	81.0
17	14.12	0.44	6.21	14.83	6.52	105	3.53	...	224,000	36,100	331,200	53,300	94.1	84.6
18	14.12	0.44	6.21	15.53	6.83	110	4.29	...	222,000	35,700	325,400	52,400	94.1	83.1
19	11.06	0.51	5.64	12.45	6.35	113	1.75	2.48	.....	.....	308,800	54,800	92.1	87.3
20	11.06	0.51	5.64	14.74	7.52	133	2.21	2.99	160,000	28,400	309,400	54,900	92.1	87.5
21	11.06	0.51	5.64	16.59	8.46	150	2.54	3.41	177,000	31,400	316,500	56,100	92.1	89.5

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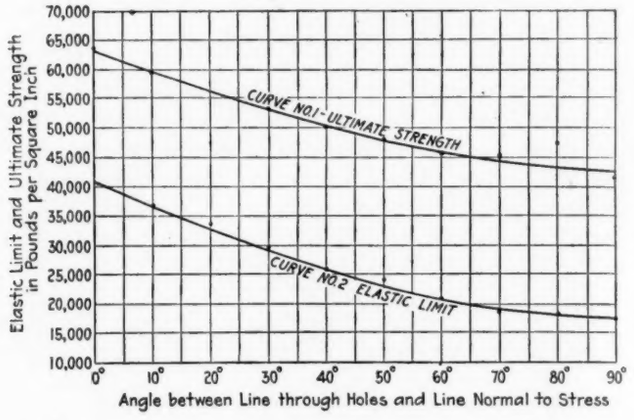
have agreed more closely with those obtained with the first ten specimens. Again, in these specimens the material was given more opportunity to stretch where its continuity was not wholly broken than if the stress was transferred from one plate to the other by rivets.

Specimen No. 13 was watched with especial interest, as the proportions conformed to those required as a minimum by the Canadian Rules, and also by the recent A. S. M. E. Code. Specimens Nos. 14 and 15 broke directly across, the third hole showing less deformation as the proportion of material increased diagonally.

It would be interesting in the line of further investigating of this condition to have the five specimens 11 to 15 inclusive prepared with exactly the same spacing of holes, only in the form of a butt joint with double strap, the double shearing strength of rivets being sufficient to insure a plate failure.

Specimen No. 16 broke through the three holes at an ul-



RESULTS OBTAINED WITH FIRST TEN SPECIMENS

timate load far below the strength according to the methods of calculation used in the various boiler rules. This failure shows a rather astonishing condition in the ordinary type of quadruple butt joint. The condition has apparently existed for years without being given much consideration. In designing these joints the practice has been to find the weakest part by calculating eight possible methods of failure. Yet, what is the use of such calculations if the actual method of failure has not been considered at all? No matter if the ultimate strength by the real method of failure may be only very slightly below the calculated strength, so long as the condition exists at all, to be consistent a proper investigation should be made. It is a significant fact that this type of joint is not recognized by the various Canadian Rules, which we believe are patterned after the Code of the British Board of Trade.

Another feature noted in these tests was that in several of the samples which failed straight across the elastic limit indicated by the scaling of the plate was first shown along the diagonal lines, which under the conditions would perhaps be the proper criterion for judging the weakest section.

Another important point to be noted was that in the narrow specimens Nos. 12, 13, 14 and 15, with a 4-in. pitch, the ultimate strength came fully up to that which might be expected from the mill-test report, but as the specimens grew wider they fell far below. In specimens Nos. 19, 20 and 21, the calculated strength as compared with the solid plate should be 92.1 per cent., but actually was only 87.3 per cent., 87.5 per cent. and 89.5 per cent.; and in specimens Nos. 16, 17 and 18, where the strength should be 94.1 per cent. of the solid plate, it actually was only 81.0, 84.6 and 83.1 per cent. These results bear out exactly the statement made with reference to wide pitches by James E. Howard in his paper read last December before the Society of Naval Architects and Marine Engineers.

In this question of the proper back pitch, or distance between rows, the design should have some excess strength in favor of the material diagonally and not be merely a balance. Really, this part of the proportioning of any joint is a feature of the design preliminary to the proper calculation by the usual methods. In considering the different possible methods of failure, if no direct calculations are made for the strength diagonally, the proportions should be such that there is no possibility of the joint failing in that manner; or in other words, whatever the method of failure may be, it should be among those for which direct calculations are made.

These tests, which will perhaps open the way for further research along this line, tend to arouse suspicions as to our high efficiencies. If the 94 per cent. and more of the strength of the solid plate are not dependable figures, we may again be falling back on our old friend the "factor of safety" to make up the difference between actual and assumed conditions.

Phenix Oil and Graphite Cylinder Lubricator

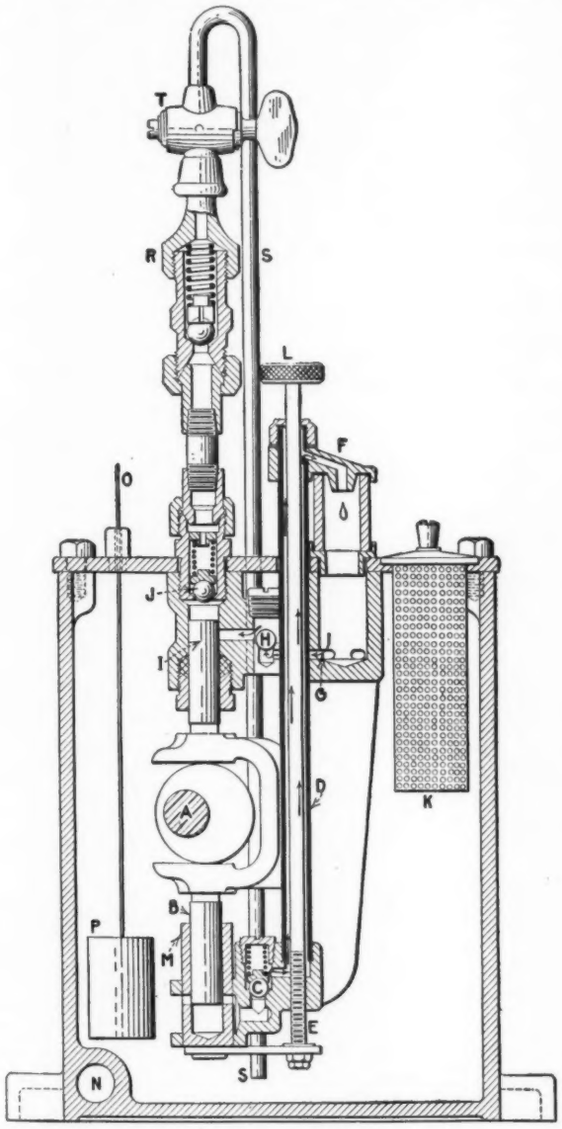
Quite recently the Richardson-Phenix Co., of Milwaukee, Wis., has placed on the market an oil and graphite lubricator provided with an agitator that continually discharges puffs of air into the oil reservoir. This keeps the graphite uniformly mixed with the oil and obviates the trouble usually experienced when attempting to feed graphite to the cylinders of steam-using equipment. Referring to the accompanying illustration, the lever operating the lubricator is given a reciprocating motion from some external source such as the valve gear of the engine. By means of a ratchet which has four go-ahead and two retaining pawls, the lever arm causes shaft *A* to revolve in one direction, rotating the cam and causing the yoke to reciprocate vertically for each feed.

Upon the upper stroke of piston *B* the oil and graphite mixture is drawn into cylinder *M*. On the downward stroke of the piston the mixture is forced up through the check valve *C* and tube *D*, thence down through the opening *F* and the sight-feed glass to chamber *G*. From the bottom of the chamber the mixture is drawn up past check valve *H* by the downward stroke of the piston *I*. On its upward stroke the piston forces the mixture through check valve *J*, out into the feed line to the terminal check valve. In the illustration a section through the agitator nozzle is shown, but the oil and graphite feed is exactly the same. The terminal check valve is inserted in the steam pipe above the throttle or into the steam-inlet passage to the valve, and the incoming steam picks up the graphite and oil from the atomizer nozzle.

To fill the lubricator, oil is poured into strainer *K*. The quantity of oil and graphite fed for each stroke of the pump *B* is regulated by means of an adjusting nut *L*. To the lower end of the adjusting rod is attached a metal strip carrying the cylinder *M*. Turning the nut in a right-

hand direction lowers the rod and sleeve so that on its downward stroke the plunger *B* does not go to the end of the cylinder. Thus, a portion of the oil remains in the cylinder and only a small quantity is forced up through the sight-feed. Turning the nut in the opposite direction raises the sleeve to its highest point and increases the feed to the maximum.

To keep the oil warm when the lubricator is used in cold places, a cored opening *N* has been provided, so that a



SECTION THROUGH OIL AND GRAPHITE CYLINDER LUBRICATOR

steam line can be connected if desired. A gage-glass shows the level of the mixture in the reservoir, and as some kinds of graphite are liable to form a deposit on the glass, a float-operated indicator is also provided. This consists of a rod *O* operated by a float *P*.

The agitator unit is exactly the same as the mixture feeding pump except that only enough of the mixture is pumped by the lower plunger *B* to provide a seal for the top plunger *I* which handles air drawn in through a vent in the top cover of the sight-feed glass. The air is compressed beneath the check valve *R* to a pressure of about 300 lb.; when the resistance of the spring is overcome, the air is discharged with a puff through pipe *S* to the bottom of the oil tank. These frequent discharges keep the graphite uniformly distributed throughout the oil. A three-way cock *T* is inserted over the check valve, so that it may be determined whether or not the agitator is working properly.

By turning the handle to the horizontal position a by-pass to atmosphere is opened, so that the discharge can be observed and the air pressure tested. On the agitator feeds the top of the adjusting rod *E* is slotted and the thumb-nut eliminated. The rod may be turned by a screw-driver and when the proper adjustment has been obtained, it is held in place by a locknut.

Norwegian Waterfall Concessions

At a cabinet council in Christiania, on Apr. 16, it was decided to bring in a bill to restrict further the existing laws of 1909 and 1911 in respect to waterfall concessions in Norway. The right of the state to regulate watersheds is confirmed in principle. Where public convenience is not interfered with and the regulated power does not exceed 500 hp. and is distant 12½ miles from another fall, no concession is necessary. Concessions will, as at present, be granted by the King, though with the proviso that where the regulated power exceeds 10,000 hp., or where considerable interests are involved, the terms of the concession must be submitted to the Storthing (parliament) for discussion. The existing maximum period of 80 years for a concession is reduced to 60 years, though in special cases, and with the sanction of the Storthing, it can be extended to 70 years.

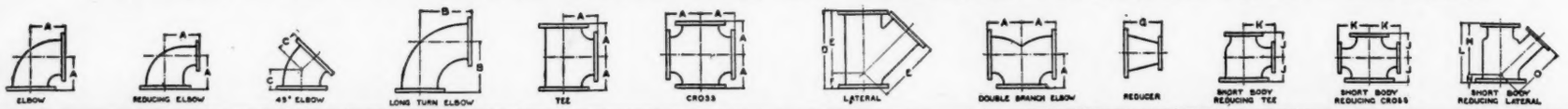
The present clause giving to Norwegian citizens and Norwegian joint-stock companies an unlimited period of concession is struck out, but is maintained in respect of Norwegian communes. At the termination of the concessional period the state can demand the transfer to it of the undertaking, with its lands, buildings, etc., without any compensation whatever. As regards concessions for a shorter period than 50 years, an amount can be fixed for the redemption by the state of the whole or a portion of the constructional work, based on the original cost of the lands, buildings and plant, according to its technical value, less amortization.

At the end of 40 years from the date of the concession the state is entitled to take over the entire proposition at its original construction cost and the plant at its technical value. This right may, if it be more convenient to the state, be postponed to periods of 10 years subsequent to the 40 years mentioned.

An important provision is an increase in the maximum royalty to the state per horsepower from 26c., as at present, to 52c., plus 26c. to the commune, or 78c. in all; though in special cases the total to state and commune can be increased to $1.04 per horsepower. There are, moreover, obligatory clauses relating to the supply to the state and commune of power at fixed prices and the use for the public of bridges and roads constructed by the party receiving the concession.

The proposed bill, the drastic restrictions of which are directed against foreign exploitation, is viewed with much disfavor by the progressive element in Norway. It is feared that its provisions with wages at the continental level, the 8-hour a day pending, and taxes at the breaking point will do away with the notion abroad that Norwegian waterpower is cheap.

THE 1915 U. S. STANDARD SCHEDULE OF FLANGED FITTINGS AND FLANGES



STANDARD WEIGHT 125 LBS. WORKING PRESSURE

SIZE	A	B	C	D	E	F	G	Short Body Red. Tees & Crosses: Size of Outlets	J	K	Short Body Red. Laterals: Size of Branches	L	M	N	O	Flanges: Diameter	Thickness	Bolts: Diameter of Bolt Circle	Number of Bolts	Diameter of Bolts	Minimum Metal Thickness
1	3½	5	1¾	7½	5¾	1¾										4	7/16	3	4	7/16	7/16
1¼	3¾	5½	2	8	6¼	1¾										4½	½	3⅜	4	½	7/16
1½	4	6	2¼	9	7	2										5	9/16	3⅞	4	½	7/16
2	4½	6½	2½	10½	8	2½										6	5/8	4¾	4	⅝	7/16
2½	5	7	3	12	9½	2½										7	11/16	5½	4	⅝	7/16
3	5½	7½	3	13	10	3	6									7½	¾	6	4	⅝	7/16
3½	6	8½	3½	14½	11½	3	6½									8½	13/16	7	4	⅝	7/16
4	6½	9	4	15	12	3	7									9	15/16	7½	8	⅝	½
4½	7	9½	4	15⅛	12½	3	7½									9¼	15/16	7¾	8	¾	½
5	7½	10¼	4½	17	13½	3½	8									10	15/16	8½	8	¾	½
6	8	11½	5	18	14½	3½	9									11	1	9½	8	¾	9/16
7	8½	12¾	5½	20⅛	16½	4	10									12½	1 1/16	10¾	8	¾	⅝
8	9	14	5½	22	17½	4½	11									13½	1⅛	11¾	8	¾	⅝
9	10	15¼	6	24	19½	4½	11½									15	1⅛	13¼	12	¾	11/16
10	11	16½	6½	25½	20½	5	12									16	1 3/16	14¼	12	⅞	¾
12	12	19	7½	30	24½	5½	14									19	1¼	17	12	⅞	13/16
14	14	21½	7½	33	27	6	16									21	1⅜	18¾	12	1	⅞
15	14½	22¾	8	34½	28½	6	17									22¼	1⅜	20	16	1	⅞
16	15	24	8	36½	30	6½	18									23½	1 7/16	21¼	16	1	1
18	16½	26½	8½	39	32	7	19	12″ std.	13	15½	9″ std.	26	25	1	27½	25	1 9/16	22¾	16	1⅛	1 1/16
20	18	29	9½	43	35	8	20	14″	14	17	10″	28	27	1	29½	27½	1 11/16	25	20	1⅛	1⅛
22	20	31⅛	10	46	37½	8½	22	15″	14	18	10″	29	28½	1/16	31⅛	29⅛	1 13/16	27¼	20	1¼	1 3/16
24	22	34	11	49½	40½	9	24	16″	15	19	12″	32	31½	1/16	34½	32	1⅞	29½	20	1¼	1¼
26	23	36½	13	53	44	9	26	18″	16	20	12″	35	35	0	38	34¼	2	31¾	24	1¼	1 5/16
28	24	39	14	56	46½	9½	28	18″	16	21	14″	37	37	0	40	36½	2 1/16	34	28	1¼	1⅜
30	25	41½	15	59	49	10	30	20″	18	23	15″	39	39	0	42	38¾	2⅛	36	28	1⅜	1 7/16
32	26	44	16				32	20″	18	24						41¼	2⅛	38½	28	1⅜	1½
34	27	46½	17				34	22″	19	25						43¾	2 5/16	40½	32	1⅜	1 5/16
36	28	49	18				36	24″	20	26						46	2⅜	42¾	32	1½	1⅝
38	29	51½	19				38	24″	20	28						48¼	2⅜	45¼	32	1⅝	1 11/16
40	30	54	20				40	26″	22	29						50½	2½	47¼	36	1⅝	1¾
42	31	56½	21				42	28″	23	30						53	2⅝	49½	36	1⅝	1 15/16
44	32	59	22				44	28″	23	31						55½	2⅝	51¾	40	1⅝	1⅞
46	33	61½	23				46	30″	24	33						57½	2 11/16	53¾	40	1⅝	1 15/16
48	34	64	24				48	32″	26	34						59½	2¾	56	44	1⅝	2
50	35	66½	25				50	32″	26	35						61¾	2¾	58¼	44	1¾	2 1/16
52	37	69	26				52	34″	27	36						64	2⅞	60¼	44	1¾	2⅛
54	39	71½	27				54	36″	29	37						66½	3	62¾	44	1¾	2⅜
56	41	74	28				56	36″	29	39						68¾	3	65	48	1¾	2¼
58	42	76½	29				58	38″	31	40						71	3⅛	67¼	48	1¾	2 5/16
60	44	79	30				60	40″	33	41						73	3⅛	69½	52	1¾	2⅞
62	45	81½	31				62	40″	33	42						75⅝	3¼	71¾	52	1⅞	2⅛
64	47	84	32				64	42″	34	44						78	3¼	74	52	1⅞	2⅛
66	48	86½	33				66	44″	35	45						80	3⅜	76	52	1⅞	2⅜
68	50	89	34				68	44″	35	46						82¼	3⅜	78¼	56	1⅞	2 1/16
70	51	91½	35				70	46″	37	47						84½	3½	80½	56	1⅞	2⅛
72	53	94	36				72	48″	40	48						86½	3½	82½	60	1⅞	2 1/16
74	54	96½	37				74	48″	40	49						88½	3⅝	84½	60	1⅞	2⅜
76	56	99	38				76	50″	42	50						90¾	3⅝	86½	60	1⅞	2 15/16
78	58	101½	39				78	52″	43	52						93	3¾	88¾	60	2	3
80	59	104	40				80	52″	43	53						95½	3¾	91	60	2	3 1/16
82	60	106½	41				82	54″	44	54						97½	3⅞	93¼	60	2	3⅛
84	62	109	42				84	56″	47	56						99¾	3⅞	95½	64	2	3 3/16
86	63	111½	43				86	56″	47	57						102	4	97¾	64	2	3¼
88	65	114	44				88	58″	48	58						104¼	4	100	68	2	3 5/16
90	67	116½	45				90	60″	50	61						106½	4⅛	102¼	68	2⅛	3⅜
92	68	119	46				92	60″	50	62						108¾	4⅛	104½	68	2¼	3½
94	69	121½	47				94	62″	52	63						111	4¼	106¼	68	2⅛	3 7/16
96	71	124	48				96	64″	53	64						113½	4¼	108½	68	2¼	3⅝
98	73	126½	49				98	64″	53	65						115¾	4⅜	110¾	68	2¼	3 11/16
100	74	129	50				100	66″	55	67						117¾	4⅜	113	68	2¼	3¾

EXTRA HEAVY 250 LBS. WORKING PRESSURE

SIZE	A	B	C	D	E	F	G	Short Body Red. Tees & Crosses: Size of Outlets	J	K	Short Body Red. Laterals: Size of Branches	L	M	N	O	Flanges: Diameter	Thickness	Bolts: Diameter of Bolt Circle	Number of Bolts	Diameter of Bolts	Minimum Metal Thickness
1	4	5	2	8½	6½	2										4½	11/16	3⅛	4	½	½
1¼	4¼	5½	2½	9½	7¼	2¼										5	13/16	3⅝	4	½	½
1½	4½	6	2¾	11	8½	2½										6	15/16	4½	4	½	½
2	5	6½	3	11½	9	2½										6½	⅞	5	4	⅝	½
2½	5½	7	3½	13	10½	2½										7½	1	5⅞	4	⅝	½
3	6	7⅝	3½	14	11	3	6									8¼	1⅛	6⅝	8	¾	7/16
3½	6½	8½	4	15½	12½	3	6½									9	1 3/16	7¼	8	¾	7/16
4	7	9	4½	16½	13½	3	7									10	1¼	7⅞	8	⅞	½
4½	7½	9½	4½	18	14½	3½	7½									10½	1 5/16	8½	8	⅞	½
5	8	10½	5	18½	15	3½	8									11	1⅜	9¼	8	⅞	9/16
6	8½	11½	5½	21½	17½	4	9									12½	1 7/16	10⅝	12	⅞	9/16
7	9	12¾	6	23½	19	4½	10									14	1½	11⅞	12	1	⅝
8	10	14	6	25½	20½	5	11									15	1⅝	13	12	1	11/16
9	10½	15¼	6½	27½	22½	5	11½									16¼	1¾	14	12	1	11/16
10	11½	16½	7	29½	24	5½	12									17½	1⅞	15½	16	1	¾
12	13	19	8	33½	27½	6	14									20½	2	17¾	16	1⅛	1
14	15	21½	8½	37½	31	6½	16									23	2⅛	20¼	20	1⅛	1⅛
15	15½	22¾	9	39½	33	6½	17									24½	2 5/16	21½	20	1¼	1 5/16
16	16½	24	9½	42	34½	7½	18									25½	2¼	22½	20	1¼	1¼
18	18	26½	10	45½	37½	8	19	12″ std.	14	17	9″ std.	34	31	3	32½	28	2⅝	24¾	24	1¼	1⅜
20	19½	29	10½	49	40½	8½	20	14″	15½	18½	10″	37	34	3	36	30½	2½	27	24	1⅜	1½
22	20½	31⅛	11	53	43½	9½	22	15″	16½	20	10″	40	37	3	39	33	2⅝	29¼	24	1½	1 9/16
24	22½	34	12	57⅛	47½	10	24	16″	17	21½	12″	44	41	3	43	36	2¾	32	24	1⅝	1⅝
26	24	36½	13				26	18″	19	23						38¼	2 13/16	34½	28	1⅝	1 13/16
28	26	39	14				28	18″	19	24						40¾	2 15/16	37	28	1⅝	1⅞
30	27½	41½	15				30	20″	20½	25½						43	3	39¼	28	1⅝	2
32	29	44	16				32	20″	20½	26½						45¼	3⅛	41½	28	1⅞	2⅛
34	30½	46½	17				34	22″	22	28						47½	3¼	43½	28	1⅞	2¼
36	32⅛	49	18				36	24″	23½	29½						50	3⅜	46	32	1⅞	2⅜
38	34	51½	19				38	24″	23½	30½						52¼	3 7/16	48	32	1⅞	2 7/16
40	35½	54	20				40	26″	25	31½						54½	3⅝	50½	36	1⅞	2 9/16
42	37	56½	21				42	28″	26½	33½						57	3 11/16	52¾	36	1⅞	2 11/16
44	39	59	22				44	28″	26½	34½						59¼	3¾	55	36	2	2 13/16
46	40¼	61½	23				46	30″	27½	35½						61½	3⅞	57¼	40	2	2⅞
48	42	64	24				48	32″	29	37½						65	4	60¾	40	2	3

EXPLANATORY NOTES

1. Standard and Extra Heavy Reducing Elbows carry same dimensions center to face as regular Elbows of largest straight size.
2. Standard and Extra Heavy Tees, Crosses and Laterals, reducing on run only, carry same dimensions face to face as largest straight size.
3. If Flanged Fittings for lower working pressure than 125 lbs. are made, they shall conform in all dimensions except thickness of shell, to this standard and shall have the guaranteed working pressure cast on each fitting. Flanges for these fittings must be standard dimensions.
4. Where long turn fittings are specified, it has reference only to Elbows which are made in two center to face dimensions and to be known as Elbows and Long Turn Elbows, the latter being used only when so specified.
5. All standard weight fittings must be guaranteed for 125 lbs. working pressure and extra heavy fittings for 250 lbs. working pressure, and each fitting must have some mark cast on it indicating the maker and guaranteed working steam pressure.
6. All extra heavy fittings and flanges to have a raised surface 1/16″ high inside of bolt holes for gaskets. Thickness of flanges and center to face dimensions of fittings include this raised surface.
   Standard weight fittings and flanges to be plain faced.
   Bolt holes to be 1/8″ larger in diameter than bolts.
   Bolt holes to straddle center lines.
7. Size of all fittings scheduled indicates inside diameter of ports.
8. Square head bolts with hexagonal nuts are recommended.
9. Double Branch Elbows, Side Outlet Elbows and Side Outlet Tees, whether straight or reducing sizes, carry same dimensions center to face and face to face as regular tees and elbows.
10. Bull Head Tees or Tees increasing on outlet, will have same center to face and face to face dimensions as a straight fitting of the size of the outlet.
11. Tees, Crosses and Laterals 16 inches and smaller, reducing on the outlet, use the same dimensions as straight sizes of the larger part.
    Sizes 18 inches and larger, reducing on the outlet, are made in two lengths depending on the size of the outlet as given in the table of dimensions.
12. For fittings reducing on the run only a long body pattern will always be used.
    Y's are special and made to suit conditions.
    Double Branch Elbows are not made reducing on the run.
13. Steel Flanges, Fittings and Valves are recommended for Superheated Steam.

This schedule, superseding all previous issues, was adopted Mar. 20, 1914, by a Joint Committee of the National Association of Master Steam and Hot Water Fitters, the American Society of Mechanical Engineers and the Committee of Manufacturers on Standardization of Fittings and Valves, and became effective Jan. 1, 1915. All dimensions are in inches. Copies of the original chart, of which this is a reproduction, on heavy paper, 24x36 in., can be secured for $1 by addressing the National Association of Master Steam and Hot Water Fitters, 260 Broadway, New York City.

Editorials

Classification of Technical Literature

On another page is reported the organization by some twenty national technical and scientific societies of a Joint Committee on Classification of Technical Literature. As its name indicates, its purpose is to propose a standard method of classifying technical literature so that filing may be facilitated and the valuable things which are being forgotten and practically buried in the back numbers of periodicals or other sources of information may be kept easily available.

The problem before this committee is three-fold. First, to arrange a complete classification of subjects in the wide fields of technology and applied science. Second, to select or develop a notation or system of indexing for the subjects classified. Third, to set before the publishers of technical journals and books, and societies that print technical and scientific transactions and proceedings, the value of adopting the accepted classification and notation.

From the deliberations of this committee will undoubtedly come suggestions as to ways in which the papers can coöperate. It goes without saying that POWER will be glad to do its part in any such way, and undoubtedly all others will be similarly disposed, for it will be to their interest to have the value of their issues made more enduring.

POWER is not insensible either of the honor of having its editor chosen as the first chairman of the committee.

Side Lights on Hydro-Electric Plant Service

To many engineers, service in a hydro-electric generating station means almost exile. They dread the prospect of spending years in a plant situated, as they often are, many miles from a city, in a rough or mountainous district. Others see in it opportunities for maintaining a little country home and a pocket-sized farm as a "side line," but fear that the work itself will lack interest because of the absence of steam equipment, the few men required to handle the installation in normal service, and the apparent simplicity of the operating routine. They feel that the opportunity to grow may be denied the water-power plant operator—that a job of this kind may be good enough for an elderly man who fancies solitude and enjoys grubbing in a garden and counting eggs, but that it cannot appeal much to an engineer with real "pep" in his makeup.

For some men this point of view is so ingrained that it would unquestionably be a false move to accept a position in a station of this kind. It is, no doubt, partly a matter of taste whether an engineer will find satisfaction in a steam plant in the town or in a water-power station many miles from the allurements of city life. But, granted the importance of applying the personal equation to hydro-electric plant service in remote localities, it is worth realizing that this kind of work may possess both interest and opportunity if a man takes advantage of his chances. The casual visitor to a hydro-electric plant in the wilderness goes away with the impression that there is comparatively little apart from routine work for the operating staff to do. It seems to the layman merely a question of opening the gates and letting the water run through, and the wheels do the rest. Beyond oiling the governors, keeping an eye on the lubrication of main-unit and exciter bearings, putting down the half-hourly instrument readings on the log sheet and watching out for possible damage from thunder storms, life appears to be one glad, sweet song. Wages are moderate, to be sure, but the little farm does the rest, thinks the visitor, and seldom does anything arise to disturb the poise of the operating shifts.

Brethren of the water-power service know better. They appreciate that under normal conditions, with everything running smoothly, the days sometimes do seem a bit long, but the wise ones in this work find fully as much to learn as do their steam-plant brothers in the town. It is true that the design of a hydro-electric station generally "stays put" and that capital errors in layout can be corrected only at relatively high cost. In its general arrangements such a plant is a pretty rigid affair, but this does not mean that skill is not necessary to operate it efficiently. Waterwheels and generators have their economical range of output no less than steam-driven machines, and conservation of storage facilities is as important in many plants as the careful use of fuel in steam stations. The relations of weather conditions to stream flow, the changes in effective head on the wheels, accuracy with which the governing equipment operates, effect of wear in turbine blades and passages upon water consumption, prevention of ice formation within wheels, proper handling of sluice gates, and the study of voltage regulation—all challenge the interest of the engineer of inquiring mind. The opportunity for the installation of home-made apparatus in the auxiliary branches of water-power plant service is large, notably in connection with the remote control of head-gates, the prevention of leakage, recording of river, reservoir and tail-race elevations, economical repairs, and improved lighting and small power applications. When a hydro-electric plant operates in parallel with one or more other stations, the possibilities of utilizing water efficiently become even more interesting and important. The reduction of waste has not received the attention it should in some stations, while in others it has gone to such refinements as the installation of special meters for water-flow records, the subdivision of local lighting and power circuits, the inclosure of operators' quarters in electrically heated spaces of limited size, use of the more efficient types of lamps, and recirculation of transformer cooling water.

In emergencies the operator's skill is taxed to maintain continuous service, no less than in steam stations. The isolation of line troubles is almost a specialty in itself.

The man with a leaning toward investigation will find plenty to occupy himself with if he confines his attention for a time to the good points and shortcomings of alternating-current relays in relation to trouble detection and segregation on the system at large. The study of lightning protection is another big subject, worthy of unusual ability, and we repeat the profound interest always associated with the subject of waterwheel governors. As a factor in securing an all-round experience in power production, the water-driven station will be in the running for a long time to come. Its isolation but gives the keen student of this branch of engineering better opportunity to master this part of his profession. Few indeed are the cases where the mails will not bring the benefits of the technical press just as well as in the city. The laws of power production are universal in scope, and if the operator refuses to yield to the temptation to live a routine life and sticks to his purpose to become an expert on the work with which he is engaged, location becomes of secondary concern for the time being and opportunity absorbs him to a degree but little realized by the fellow who thinks that water-power service is narrowing to ambition.

State Aids Kansas Engineers

The commendably generous offer made by the Kansas State Agricultural College to assist in the educational program of the National Association of Stationary Engineers of that state will most likely be accepted. State and municipal educational institutions of an engineering or technical character might well consider following Kansas' lead.

The college offers to direct a course of study under the auspices of the State association, each subordinate association to have at least three lectures a season by a representative of the college. Special lectures on subjects allied with power-plant operation will also be given. The college aims to send out questions and references to each association. Every sixth lesson will be in the nature of an examination, the results of which will be reported to the college. The associations are expected to pay for only the traveling expenses of the lecturers; this outlay to be met by special assessment. It is the intention to begin the course July first.

The National Educational Committee of the association supports a program similar to that offered by the Kansas Agricultural College. It would seem that both programs could be carried out to the advantage of all concerned.

Cleanliness in Refrigeration Plants

To the mind of the layman cleanliness implies absence of dirt. To the engineer it means, or should mean, absence of anything foreign to the machine or apparatus or its functioning. As someone has said, "Dirt is matter out of place."

The refrigeration plant is a place of transmissions. Not the noisy, evident processes heard and seen in turbine or engine rooms or in shaft alleys or belt races, but the quiet, invisible transmission of heat through metal walls. You cannot see it. Sometimes in some places the hand, sensitive as it is to temperature differences, cannot inform even approximately how effectively this transmission, which is so vitally necessary to the plant's efficiency, is going on.

Elaborate, extensive and expensive tests have been conducted to reduce to accurate figures the losses due to scale in boilers, because scale is an undesirable insulator between heat and the water that should absorb it—because it is dirt; because it is foreign.

The refrigeration plant is a great rendezvous of similar foreign substance or substances having similar effects. If the condensers are scaled the heat-laden ammonia cannot get rid of its heat as it should, and it starts on its heat-absorbing journey handicapped and partly incapacitated. If this were all it would not be so bad; but when this ammonia arrives at the working place, at the cooler and the coils, the same coils may be so insulated with ice or scale, or both—and both are foreign, both may be considered dirt, because they are matter in the wrong place—that the half-able ammonia cannot even do what it is willing to do. The compressor water-jackets, the absorber, the generator, the precooler, the cooling tower—all may be likewise coated with dirt. Even the noncondensible gases may be considered as dirt and are worse than scale or ice, because they circulate.

The whole system must be as clean as a freshly laundered shirt if it is to work well. How to keep it clean and working well is the engineer's job. He is the laundryman as well as the maker of the shirt, which in this case happens to be refrigeration. The articles now appearing in POWER tell him in that good old shop-talk way how to do it best. They are useful articles, these; and we hope to have more of them.

Motor Records Again

Engineers in charge of industrial power plants are more and more being made responsible for the quality of motor service rendered on the premises. Even where the establishment carries one or two electricians on its payroll, the chief engineer is likely to be blamed for motor troubles, and the anticipation and prevention of these deserve some attention. Motors of the induction type, if built by reputable concerns, will stand a large amount of abuse, it is true, but the furnishing of efficient service is today demanded almost as much as regular operation, and superficial knowledge of what the local motors are doing is a pitfall into which the steam engineer in executive charge of this branch of the installation should not allow himself to fall.

The larger the plant, the more justifiable it is to keep accurate records of the repair items on individual machines, the performance of different makes, any tendencies toward heating of bearings or moving parts, and the repeated need of adjustment of air-gap conditions, alignment of bearings, or commutator difficulties, where direct-current motors are used. The value of card-index test records of loads carried has been emphasized in these columns; of equal importance is the maintenance of a high power factor in alternating-current installations. Protracted underloading of individual motors leads to overheating of generators from excessive idle current, and the study of manual versus solenoid control for motors on machine tools is one of large interest.

Correspondence

Depth of Stuffing-Box

The writer has had the same trouble with an outside-packed pump as described by C. E. Sherman in the issue of Apr. 6, 1915, page 481. In my case it was overcome by fitting a dummy packing of lignum-vitæ two inches deep and filling the stuffing-box with soft packing. This means of packing removed all trouble and considerably reduced the friction losses.

For low pressures white-metal shavings, with a turn of soft packing before and after, will give good results.

E. R. Pearce.

Rochdale, England.

Isometric Drawings

Most power-plant engineers can make pencil sketches of the general appearance of parts of machinery, showing the dimensions and thus conveying the desired information to others. Most men would probably draw freehand two or three views on the back of a report sheet and write in such information as they thought the drawing failed to give. A sketch in isometric perspective, or sort of a bird's-eye view, necessitates but one view and is easy to make, yet engineers generally think it beyond their

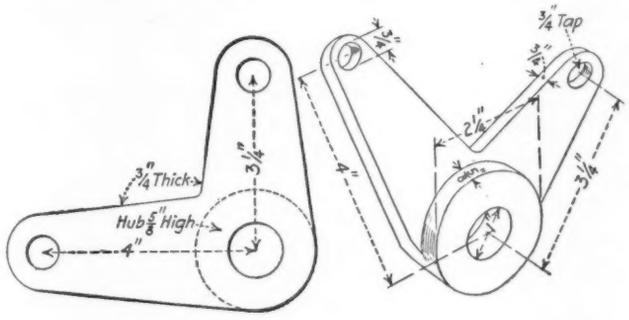


Fig. 1. Fig. 2.

Advantages of Isometric Sketches

ability. Such a sketch shows the parts in their true relation best and is really easier to draw.

In a number of cases repair parts made from drawings capable of being misinterpreted have resulted in expensive mistakes. One instance will illustrate. A Corliss engine broke one of the bell cranks. The engineer took the gear apart and sent a helper in with a sketch of the broken piece, Fig. 1. I could see that he had laid the broken crank on the paper and drawn a line around it, and then put on such dimensions and notes as he thought were necessary. The hub was shown dotted and there was a chance for a misunderstanding as to which side the hub should be on, so I phoned to him for the old casting. For some reason he refused to part with it and told me to make it "just as it says on that paper—and be quick about it," for he had to start up at 6:30 o'clock.

It was forged out, finished and delivered after working hours. Next morning there was a phone call for another crank made with the hub on the other side, "where it belongs." The second crank was made as shown in Fig. 2, but there was trouble when the bill for two cranks was presented. Fortunately, we had retained the engineer's drawing and the first crank.

The bill was not paid until a competent person had passed on the correctness of the work. Of course, the intentions were all right, but the mistake was in showing the hub by dotted lines, indicating a lower or invisible surface according to the rules of drawing. The engineer had not known this and had committed the error.

A little time spent in practice will make anyone fairly proficient in sketching. It is interesting and is helpful even when correct three-view drawings are at hand.

Donald A. Hampson.

Middletown, N. Y.

Clean New Steam Lines

Although steam has been used commercially for one hundred years or more and steam regulating and economizing devices have been constantly increasing, many engineers are still ignorant as to certain vital points. The greatest trouble we find is that a large percentage of engineers (and this refers to the educated men as well as the ones in overalls) will connect up an entirely new line and blow dirt, grease, white lead, red lead, iron turnings and dirt generally through separators, reducing valves and steam traps and all other devices.

Cannot you start a campaign of education along these lines? We advise wherever we have an opportunity to do so that the lines be blown through for at least forty-eight hours before connecting up the devices. Of course this wastes a lot of steam, but it is paid for a hundred times over in the avoidance of subsequent trouble.

E. E. Strong, Pres.,
The Strong, Carlisle & Hammond Co.

Cleveland, Ohio.

Explosions in Boiler Furnace*

I have read the discussion on this subject for the reason, chiefly, that we have had similar trouble, although so far no damage has been done. Mr. De Blois in the Apr. 30 issue states that his boilers are equipped with underfeed stokers. [These are of the Jones type.—Editor.] We have four boilers, horizontal water-tube, equipped with underfeed stokers (Taylor), and on several occasions there have been explosions which occurred while the fire was being worked. I have studied the conditions and believe the trouble is caused in the following manner:

The arrangement of this furnace is such that the coal is pushed into a trough, or retort, by the slow-moving plungers. It is then worked forward and upward by the plunger and incoming coal. When the coal first enters the retort it is fine and closely packed and sometimes

*See "Power," Apr. 30, p. 553; May 11, pp. 651, 652 and 653, and May 25, p. 719.

quite damp, as we wet the coal in the bunker to keep the dust down.

The air holes in the tuyeres are above this trough and about at the level where coking takes place as the coal is moved forward in the furnace. With ordinary crushed bituminous coal, usually quite fine, the greater part of the volatile hydrocarbons are driven off at about this point in the furnace and pass through the incandescent fuel bed above to the combustion chamber. After a few hours' firing a clinker will form on the tuyere plates, which partly obstructs the air passages through the tuyeres and which must be broken up and removed with the slice-bar. This is done through the small side doors. Sometimes it can be done without disturbing the green coal below the tuyeres, and at these times there have been no explosions. But at other times the upper part of the fire, or the incandescent fuel bed, is so broken or so light after getting the clinkers out that it is necessary to break the bed of green coal to level the fire. This liberates a large quantity of rich gas which is below the level of the air openings and has not a good chance to mix with the air coming through the tuyere holes. As this gas rises it comes directly across the path of the high-velocity incoming air and forms a large volume of gas that is explosive and does explode when ignited by the incandescent coke and hot side walls of the furnace. In some cases the flames, usually accompanied by a shower of sparks which I think are particles of coal dust that have been ignited, have shot out of the small doors and into the fireman's face. When the fresh coal was quite wet this explosion was sometimes strong enough to blow open the side doors. The reason that wet fuel causes a more violent explosion is, I think, because the coal is packed more closely and does not allow the gas to escape readily until the fuel is broken up with the bar.

The air pressure in the wind-box at the time these explosions occur is usually about 1.8 to 2.5 in. of water. The boiler damper is usually wide open, and the draft over the fire is maintained at about 0.2 to 0.3 in. of water in the front pass.

Mr. De Blois asks for suggestions as to how to prevent these explosions. I do not know how his furnace is constructed or how the fan is controlled, but in our case the speed of the fan engine, which also drives the stokers, is controlled by a damper regulator which, instead of being connected to the dampers, is connected to a butterfly valve in the steam line to the engine. When the pressure drops about 1 lb. the engine speeds up to about 450 r.p.m. This creates considerable air pressure in the tuyeres, as the steam pressure is usually a little low at this time, and when the green coal is moved with the slice-bar a large volume of explosive gas is liberated.

As a remedy for this trouble I would suggest two changes in the operation, either of which will bring about similar results. First, before the fires are worked with the bar in cleaning or leveling, close the gate in the air-supply pipes, which the fireman will probably not do unless specially instructed. Second, change the methods of control of the fan so that the air pressure will be constant and will change only as the load changes, or in other words, make the air pressure proportional to the load carried by the boilers. The first change will prevent sufficient air from entering the furnace at the time when the rich gas is being driven off to cause an explosion, the gas escaping to the stack. The doors are so small that only a small volume of air can enter at this point, and the air that can filter in through the setting at this low draft pressure is negligible so far as explosions are concerned. The second change would give an even air pressure at all times and might prevent a proper mixture of explosive gas. It also has the advantage of giving a uniform rate of combustion with only the minimum amount of excess air, a condition which makes for economy.

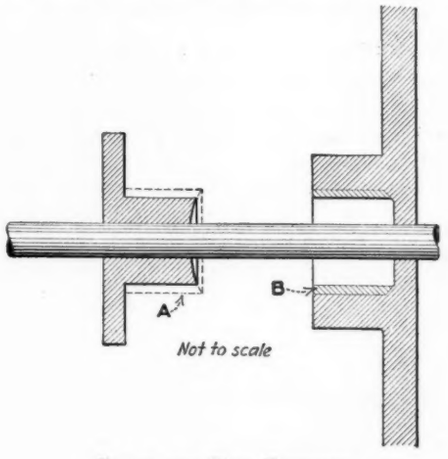
I have never known an explosion to occur except when the front doors were open, but this is the time when the coal is being disturbed, and the air probably comes through the tuyeres instead of through these doors.

J. C. HAWKINS.

Hyattsville, Md.

Changed Proportions of Stuffing-Box

After having a great deal of trouble with the packing on one of my engine rods, I overcame it as follows:



STUFFING-BOX BUSHED

The rod was 2 in. and the packing 7/8 in., which is too large for a rod of that size, so I made a bushing 1/4 in. thick and drove it into the stuffing-box, as at *B*, turned 5/16 in. off the gland at *A* and used 5/8-in. packing, which works to perfection. This engine makes a 60-day run of 24 hours without a stop, with a piston speed of 400 ft. There has been no trouble with the packing during the last 45 days.

M. J. MERRELL.

St. Louis, Mo.

Grouting under Heavy Machinery*

With small engines—those weighing six or seven tons—six wedges, 2 in. wide, 8 in. long and 1/4 in. thick at the point by 5/8 in. at the butt, are quite sufficient if distributed one at each corner and one in the middle of the frame at each side and all removed as soon as the grout has set. When the engine has been leveled up with a 5/8-in. space left for grouting, a dam of clay or mortar should be built around the bed so as to let the grout stand two inches up the side of the bed. The grout should be two parts clean, sharp sand and one of cement,

*See previous discussion, Mar. 2, p. 310; Apr. 6, p. 482; May 4, p. 620.

mixed to the consistency of thick buttermilk and run in (the bolt holes having first been surrounded with clay). Mr. Wilson speaks of borings and ammonia; this is all right for small jobs, but hardly feasible with a big machine.

The old-fashioned way of bedding down to a stone bed was good, as the stones were very little affected by oil, whereas many foundations have been ruined by oil getting between the bed and engine.

Care should be taken to remove all traces of oil before pouring the grout and it should not be allowed to set too quickly. This may be retarded in a hot room by covering the exposed parts with burlap which should be kept wet. Always make sure that there is a free escape for the air from the inside of the box beds, otherwise the grout will not flow evenly to all parts.

E. R. Pearce.

Rochdale, England.

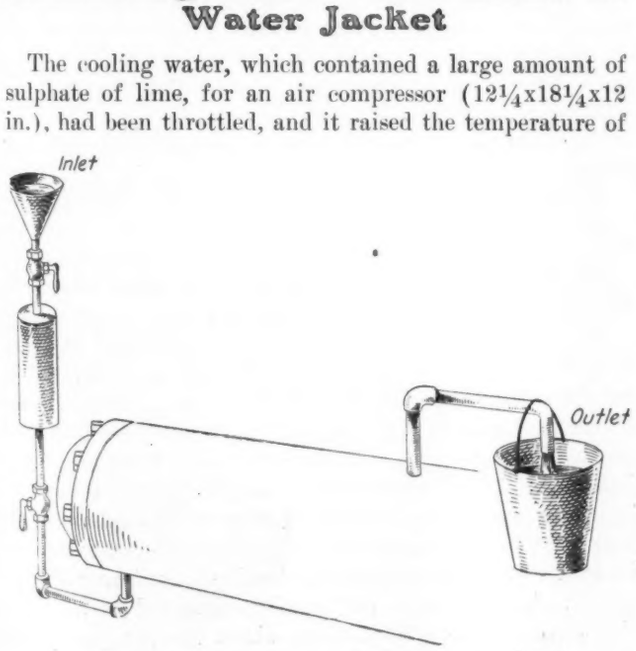
In the issue of Apr. 4, p. 620, J. E. Poche advocates using iron wedges in leveling up machinery preparatory to grouting in. Wedges of this kind serve very well for leveling up, but should not be left in as he recommends, as the base of the machine will rest on the wedges and not on the concrete. We tried it once and had to dig the grouting out and do the job over, because of the engine sliding on the iron wedges. I prefer wedges of hardwood for this work.

J. O. Benefiel.

Anderson, Ind.

Removing Scale from Inside of Water Jacket

The cooling water, which contained a large amount of sulphate of lime, for an air compressor (12¼x18¼x12 in.), had been throttled, and it raised the temperature of



Acid Piped into Water Jacket to Remove Scale

water so that it deposited inside of the cylinder jacket a hard scale which we could not get at to remove with tools. I used muriatic acid piped through as shown in the illustration, and it worked fine. It took ten gallons at 60c. per gallon to do the job.

To operate, close the lower valve and fill the reservoir with acid, then close the upper and open the lower valve. The acid forces its way through and disintegrates the scale in the jacket. I used the acid over again as long as it had any strength.

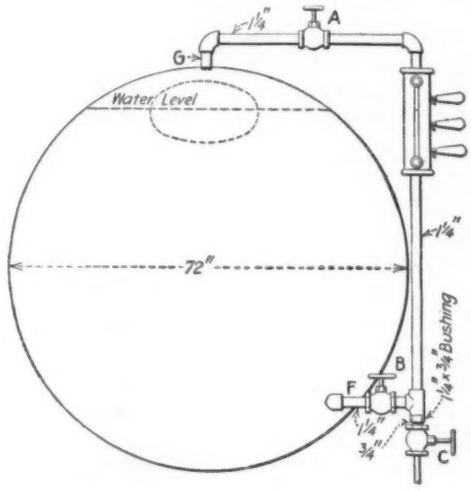
W. A. Hendry.

Grinnell, Iowa.

Queer Action in a Water Column

I hesitate to tell the following experience with a 72 ft. by 17 ft. 6 in. horizontal return-tubular boiler, for I would not believe it myself until I had actually seen it.

The boiler had been out of service for a few days for cleaning and repairs. When it was ready again the



Water Column as Connected

fireman replaced the manheads and started to fill it with water. (It has been the custom at this plant when filling a boiler to leave all connection closed till an air pressure of about 20 or 30 pounds has been reached; then, if either manhead gasket is defective it will show it at this pressure and can be changed without having to pull the fire.) When the fireman returned to this boiler he found the water showing at the top of the water-glass. He immediately shut off the water-feed valve and opened the blowoff to drain out the water to the proper level for firing up. But he had no sooner opened the blowoff valve than the water disappeared in the gage-glass and did not return. He then closed the blow-off and opened the feed-water valve, and the water immediately rose to the top of the glass again. He repeated this performance several times, with the same result each time, and then called in the foreman who also obtained the same results. He then shut both the blowoff and the feed valves and opened valve *C* (valves *A* and *B* being already open), and there was a strong suction of air into the boiler. Valve *B* was next closed, with valves *A* and *C* open, and water rushed out with considerable force. Valve *A* was then closed, with *B* and *C* open, and the water immediately stopped running, but there was no suction. On opening valve *A*, however, with valves *B* and *C* open, the suction commenced again and the water could be seen rushing upward through the gage-glass.

These valve changes were made many times, with the same results. With valves *A* and *B* open and *C* closed, the water sometimes showed at one height in the glass and sometimes at another. It finally came to rest at a

point a little below the third gage-cock, but the suction continued when valves *A*, *B* and *C* were opened, and water rushed out when valve *B* was closed, with *A* and *C* open, as before.

It was finally decided to take out the rear manhead to see the actual location of the water level. Before doing this, however, valves *A*, *B* and *C* were again opened and the suction was as strong as ever. Valve *C* was closed and the water level, after some fluctuation, came to rest in the glass a little below the third gage-cock. The rear manhead was then loosened, but instead of falling in as was expected, there seemed to be a heavy pressure holding it in place. It required several sharp blows with a heavy bar to loosen the head. When it was finally driven in air and water spurted out as if from heavy pressure. The water level was found to be about as the level in the glass had last shown it.

The boiler was then emptied and all the pipe connections of the water column removed and examined. The lower horizontal pipe marked *F* was partly closed with scale, but still had a free opening of ample area, and the rest of the pipe and the water column itself were perfectly clear.

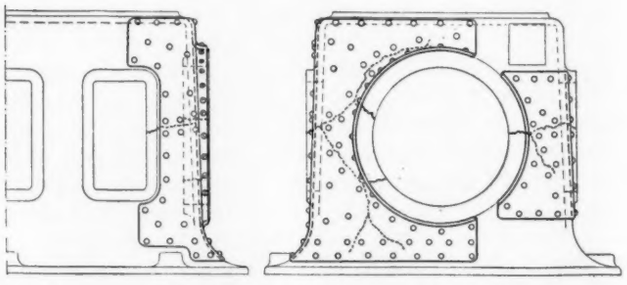
Now, if anyone can satisfactorily explain how vacuum and pressure can exist in the same boiler at the same time I would like to see the explanation published in POWER. Also, why and how did the water siphon out of the boiler in a continuous stream when valve *B* was closed with *A* and *C* open? Pipe *G* did not extend through the shell of the boiler more than ½ in., and the water level was eight or ten inches below it.

F. F. JORGENSEN.

Gillespie, Ill.

Repairing Gas-Engine Housing

On one of the three-cylinder vertical 200-hp. gas engines in the local electric-light plant the housing was broken as shown by the heavy dotted lines in the illustration. The fracture began at the end bearing seat and continued around the corners and along both sides, terminating at the manholes in each side. On one side of the end



SHOWING HOW PLATE WAS RIVETED TO HOUSING

vertical center line the break extended upward and downward until there was practically no support for the bearing and shaft and part of the weight of the revolving part of the generator.

The builders of the engine advised that the least time in which they could furnish a new casting completely machined would be three weeks, which meant a serious delay for the lighting company.

A local firm guaranteed that it could repair the housing in three days from the time of delivery at its works. The offer was accepted, and a very substantial job was accomplished. The repair plates are $\frac{9}{16}$-in. boiler plate formed to fit the casting as shown, and special care was exercised to make a good fit around the circular flange at the bearing seat. Where possible the plates were secured to this flange with ¾-in. machine screws fitting in reamed holes that penetrate sufficiently into the casing flange to insure a true surface for the end face of the bearing. In the other parts ¾-in. rivets were used, and around the corners these extended through, with heads against the fillets on the inside of the housing.

On the whole this repair job, while a big one, is entirely satisfactory, and besides saving much time, proved cheaper than a new housing.

Franklin, Penn. M. E. GRIFFIN.

Priming Centrifugal Pumps

Having read the several letters in recent issues of POWER* relative to priming centrifugal pumps, I submit the following description of a method that I used successfully on a three-stage pump. This was connected to 21 drilled wells and discharged into a standpipe about 160 ft. above the pump. The wells were divided, ten on one and eleven on the other side of the pump, with a check valve in each lead.

An old belt-driven air compressor was used as a vacuum pump, and the suction was connected between the wells and the check valves. The suction pipe was run up through the chimney, which gave it a total height of 40 ft., so that the pump would not draw water into the cylinder. The pump suction pipe between the check valves and pump was filled with water and the air pump started. After the air was exhausted from the suction pipe, the centrifugal pump was started.

Marshfield, Wis. LOUIS B. CARL.

The letters on this subject appearing in recent issues of POWER are interesting and instructive.

About two years ago I installed four centrifugal pumps, each of which had a suction lift from 12 to 16 ft. The suction pipes were from 4 to 10 in. in diameter and the discharge pipes 4 to 8 in. Two of the pumps were used for pumping sewage and two for clear water. The speed was from 1250 to 1500 r.p.m., the discharge lift from 30 to 70 ft. Each suction pipe had a foot valve (they could not be kept tight on the sewage pumps) and a strainer at the inlet end. There never was any trouble in priming these pumps. The facilities for priming consisted of a 2-in. pipe connected to a tank 30 ft. above the pumps. The tank was always kept full of water.

A 1-in. branch pipe from the 2-in. line was run to each pump and a 1-in. straight-way valve put in each branch.

All the pumps had water-sealed shafts and were direct-connected to alternating-current motors from 35 to 125 hp. The valve on each discharge pipe was opened only after speeding up the pumps. From two to four minutes was the time required to prime. A vacuum gage was at-

*"Power," Mar. 2, p. 294; Apr. 6, p. 481; Apr. 20, p. 550; May 4, p. 615.

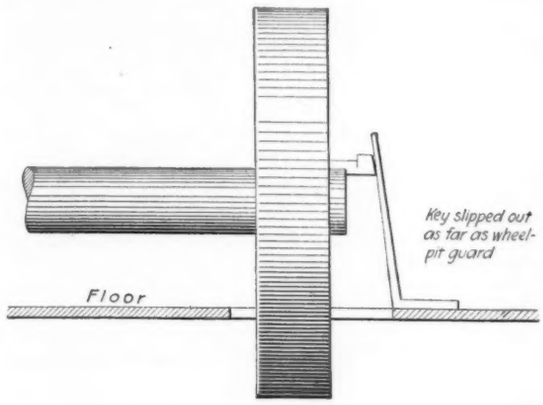
tached to each suction pipe and a pressure gage to each delivery pipe between the pump and the delivery pipe valve.

JAMES E. NOBLE.

Toronto, Ont.

An Accident Prevented

The illustration shows how a sheet-iron wheel-pit guard prevented a flywheel from slipping off the shaft and probably causing serious damage. The diameter of the wheel is only 30 in., but it is in such a position that had it slipped off it would have wrecked the main unit of the isolated plant. One of the attendants noticed that the wheel was not running true, and it was found that the key was very loose and a new one had to be made.



KEY HELD IN PLACE BY GUARD

SAMUEL L. ROBINSON.

Providence, R. I.

Comment on Turbine Lecture

I have read C. H. Bromley's lecture on steam turbines in the May 11 issue. In the latter part he offers suggestions on starting and running a turbine, and it does not appear to be clear what type of machine he had in mind.

To pick out one or two statements: "Now close the drains of the stages. The gear may then be oiled. The main turbine may vibrate considerably while being brought up to speed" . . . "to get the rotor above the 'critical speed,' when the vibration will ordinarily cease."

Mr. Bromley's opening remarks undoubtedly refer to a multi-stage turbine; in fact, one might gather that he has particular reference to a Curtis vertical machine. He then appears to refer to a De Laval single-stage impulse turbine in the same breath, as it were, for no multi-stage units are built with shafts which run above their critical speeds; in fact, to my knowledge this characteristic is peculiar to the original single-stage impulse De Laval, with its flexible shaft. I might also add that if the gears which Mr. Bromley mentions did not receive oil immediately they started to revolve, instead of after the load was thrown on, the heat generated would soon cause abrasion of the teeth.

He refers also to clearances between the blade teeth and the casing. As every turbine man knows, the radial clearances for an impulse turbine can be much greater than for a reaction, due to there being no pressure difference between the two sides of any one wheel, whereas with the reaction type these must be reduced to the smallest practical amount. There are also other statements on which comment might be made, such as, "sometimes an elevated tank is used for supplying oil at starting and stopping." The gravity system, comprising the elevated tank with cooling coils and filter placed below, is in general use.

R. N. AUSTIN.

Toronto, Ont., Can.

I was much interested in Mr. Bromley's lecture on the steam turbine, appearing in the May 11 issue of POWER, particularly in his instructions for starting.

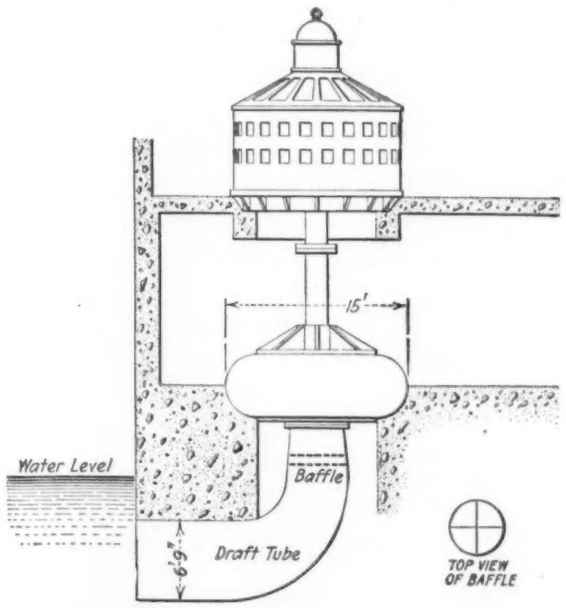
He says the turbine may vibrate considerably while being brought up to speed and that the admission of a little more steam quickly to get the rotor above the "critical speed" will ordinarily cause the vibration to cease. Although his instructions seem to apply to the Curtis turbine, this point is also true of the Westinghouse machine. If, however, the turbine is started about fifteen or twenty minutes before it is needed for the load and slowly brought up to speed, the vibration at the "critical speed" will be reduced to a minimum and in some cases done away with altogether.

JOHN TOOKER.

Richmond Hill, N. Y.

Draft-Tube Water-Hammer

Recently, there was installed in our plant, a 15,000-hp. waterwheel driving an alternator. The plant operates under 375-ft. head and the unit runs at 375 r.p.m., the pressure at the waterwheel being 158 lb. When operating at $\frac{5}{16}$ gate opening, it was found that water-hammer occurred in the draft tube, causing the pressure in the pipe line to rise 25 lb. and starting leaks in the 7-ft. wooden-pipe line.



BAFFLE IN DRAFT TUBE STOPPED WATER-HAMMER

The theory of the engineer was that, owing to the construction of the draft tube, the velocity of water at that

particular gate opening was such that the whirling motion through the wheel set up a counter-current in the center of the draft tube, causing the water to come back into the wheel and raising the pressure. The vacuum gage in the draft tube varied from 15-in. vacuum to 5-lb. back pressure under this condition of water-hammer.

The engineer stated that a baffle placed in the draft tube to break up this whirling motion would cure the trouble, and a piece of boiler plate 1 in. thick and 18 in. wide was then placed therein, as shown in the accompanying sketch.

This cured the difficulty and since then no trouble has been experienced.

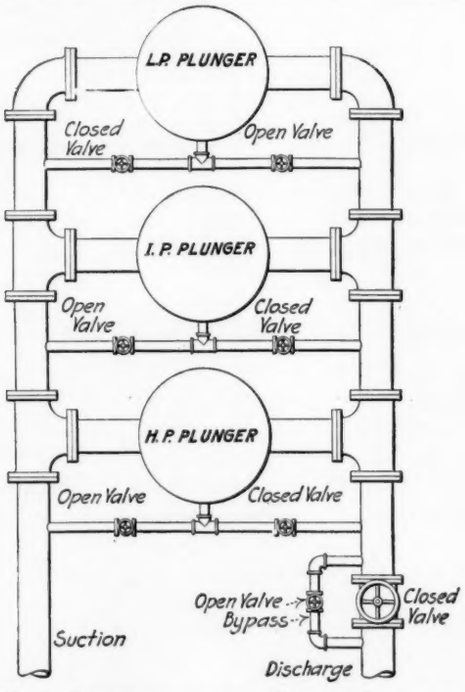
J. B. Crane.

Duluth, Minn.

Moving Pumping Engines by Water Pressure

Handling pumping engines of the large sizes calls for a method of procedure peculiar to itself. They must be moved a small distance at a time and also held securely in position.

Multiple-expansion pumping engines are not usually built with reversing gears, and it is customary to move



Pipe Connections for Water Pressure

them forward or backward a small amount with water pressure. I submit the simple illustration of the pipe connections to the plungers and valve chambers of a twenty-million gallon pump.

The engine is of the vertical triple-expansion type. The three cranks are set at 120 deg. apart. We have access to a 100-lb. water pressure which is brought to bear under the plunger whose crank happens to be in position to be raised. This moves the entire engine. By the manipulation of a set of bypasses the discharge area, plunger chamber and suction area are thrown open to water pressure and release as desired.

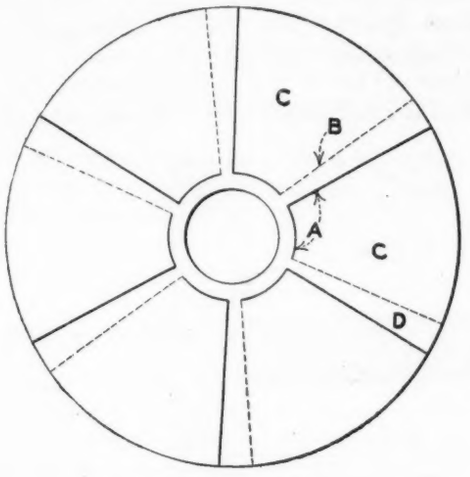
Edward T. Binns.

Philadelphia, Penn.

Increasing the Flow of Water

An appliance for increasing the amount of water that will flow through the outlet of a shallow tank when the depth of the water does not exceed three times the diameter of the outlet may be easily made in the following manner:

Cut a sheet-metal disk of suitable thickness four times the diameter of the outlet, and a hole in the center of



Disk over Tank Outlet

the disk the size of the outlet. Lay out the flange in six equal parts (see illustration). Cut the disk on the full lines marked *A* and bend on dotted lines *B*, bringing the planes *C* to a vertical position and at right angles to *D*, thus forming six wings. Place the appliance directly over the outlet, using the plane *D* as the base. The plane *C* eliminates the whirling motion of the water and allows it to run out in a steady stream.

E. A. Buchanan.

Coffeyville, Kansas.

"Unusual Opportunity" for the Fireman

When it comes to versatility for the fireman we certainly have to hand it to North Carolina. In this state he can assume such rôles as best meet any and all occasions, playing the part of fireman, scrubman, bath artist, etc., with full permission of the law. In fact the law helps him to it, as shown by the following interesting extract from the State Public General Laws of 1911, and now operative:

Section 1 (Chapter 156). That the fireman of the Supreme Court building shall be appointed by the chief justice and associate justices of the Supreme Court, and when not engaged in his duties as fireman shall act as assistant janitor of the Supreme Court, and shall assist in the cleaning and care of the Supreme Court and perform such other duties as may be designated by the said justices of the Supreme Court.

This law, granting these great privileges, is the noble work of the General Assembly. How many members of that honorable body ever visited a boiler-room to learn what firing really meant?

L. R. W. Allison.

Newark, N. J.

Inquiries of General Interest

Long-Range Cutoff for Corliss Engine—How can long range of cutoff be secured with a Corliss engine?

J. C. H.

By supplying the engine with a separate eccentric for operation of the steam valves.

Submerged Piston vs. Straightway Pump—What is the difference between a submerged piston and straightway pump?

W. C. O.

Submerged piston pumps are like the ordinary duplex feed pump with both suction and discharge valves above the water pistons, the latter being submerged, while in the straightway pattern the suction valves are below and the discharge valves above the water pistons.

Terminal Pressure—What is meant by terminal pressure?

S. H. J.

Terminal pressure is the pressure that would be in the cylinder at the end of the stroke of the piston if the exhaust valve did not open until the stroke was completed. On a steam-engine indicator diagram the terminal pressure may be found by extending the expansion curve to the end of the diagram. The theoretical terminal pressure is found by dividing the pressure at cutoff by the ratio of expansion.

Piston Displacement—What is meant by the term "piston displacement"?

C. A. G.

Piston displacement is the space, usually reckoned in cubic inches, through which the piston sweeps in a single stroke. It is found by multiplying the area of the piston, in square inches, by the stroke in inches. The displacement of a pump piston would be the number of cubic inches of water discharged by one stroke, if there were no leakage or slippage.

Spouting Velocity of Liquid—What is the "spouting velocity of a liquid?

S. H. H.

The velocity with which a liquid under pressure issues from an orifice, and unless otherwise qualified, the term is used to signify the theoretical velocity that would be due to the head or pressure of the liquid at the entrance of the orifice, as given by the formula,

$$v = \sqrt{2gh}$$

in which

v = Velocity in feet per second;
$2g$ = 64.32;
h = Head in feet, equivalent to the pressure.

Absolute Pressure for Inches of Vacuum—What would be the absolute pressure with 26 in. of vacuum and 29.5-in. barometer?

M. W. C.

Inches of vacuum signifies pressure in inches of mercury column below the pressure of the atmosphere; hence, with a barometer reading of 29.5 in., 26 in. of vacuum would represent an absolute pressure of

$$29.5 - 26 = 3.5 \text{ in. of mercury.}$$

At ordinary temperatures each inch of mercury may be taken as equal to 0.491 lb. per sq.in., therefore the absolute pressure would be

$$3.5 \times 0.491 = 1.7185 \text{ lb. per sq.in.}$$

Stacks Mounted on Boiler Settings—What are the advantages or disadvantages of having independent steel stacks set directly over the front smoke connections of return-tubular boilers?

W. L. B.

Stacks erected in that manner have the advantages of affording direct and independent draft and a saving of ground or floor space required for independent bases and foundations. They have the disadvantages of requiring special supports and also of usually requiring reinforcement of the front ends of the boiler settings to prevent the settings from being racked by wind movement of the stack. They also present difficulties in providing protection of the front end of the boiler and setting from damage by rain water carried down inside or outside of the stack.

Designation of Superheated Steam—How is the amount of superheating of steam designated and how is it usually determined?

S. W.

Superheating is designated in degrees of superheat, meaning the number of degrees by which the actual temperature of the steam exceeds the temperature of the boiling point corresponding to the pressure which is under consideration. For practical purposes the number of degrees of superheat present is usually determined by ascertaining the actual temperature of the steam by a thermometer and deducting the temperature of saturated steam for the given pressure, as found from the steam table. Thus, if the gage pressure of the steam is 150 lb. per sq.in. and a thermometer inserted in it shows that its temperature is 470 deg. F., then, as the temperature of saturated steam for the pressure is about 366 deg. F., there would be

$$470 - 366 = 104 \text{ deg. of superheat.}$$

Relative Economies of Evaporation—If, with an average temperature of feed water of 44.4 deg. F., a boiler evaporates 36,315 lb. of water into dry saturated steam at an average gage pressure of 110.4 lb. per sq.in., using 5326 lb. of coal, what would be the relative economy with an evaporation of 39,000 lb. of water from a feed temperature of 45 deg. F. into dry saturated steam at an average gage pressure of 107.6 lb. per sq.in. and using 5600 lb. of coal, the kind of coal, duration of trials and other conditions being the same?

M. T. J.

In the first instance the actual evaporation would be $36{,}315 \div 5326 = 6.818$ lb. of water per pound of coal. A pound (weight) of steam at 110.4 lb. gage pressure or about 125 lb. absolute contains 1190.3 B.t.u. above 32 deg. F., and as each pounds of feed water at 44 deg. F. contains $44.4 - 32 = 12.4$ B.t.u. above 32 deg. F., the heat received by each pound of water evaporated would be

$$1190.3 - 12.4 = 1177.9 \text{ B.t.u.}$$

As the heat required for evaporation of a pound of water from and at 212 deg. F. is 970.4 B.t.u., the factor of evaporation would be

$$1177.9 \div 970.4 = 1.2138$$

so that the evaporation of 6.818 lb. of water per pound of coal would, under the conditions, be equivalent to the evaporation of

$$6.818 \times 1.2138 = 8.2757 \text{ lb.}$$

of water from and at 212 deg. F. per pound of coal.

In the second instance the actual evaporation would be $39{,}000 \div 5600 = 6.964$ lb. of water per pound of coal. As the gage pressure of 107.6 lb. per sq.in. would be equal to about 122 lb. absolute, each pound (weight) of steam would contain 1189.8 B.t.u. above 32 deg. F. With feed water at 45 deg. F. each pound evaporated into steam would receive

$$1189.8 - (45 - 32) = 1176.8 \text{ B.t.u.}$$

the factor of evaporation would be

$$1176.8 \div 970.4 = 1.2132$$

and there would be an evaporation equivalent to

$$6.964 \times 1.2132 = 8.4487 \text{ lb. of water per pound of coal.}$$

Therefore, in the second instance there would be

$$\frac{8.4487 - 8.2757}{8.2757} \times 100 = 2.09 \text{ per cent.}$$

more water evaporated per pound of coal, and for evaporation of the same quantity of water the percentage less of coal would be

$$\left(\frac{1}{8.2757} - \frac{1}{8.4487}\right) \times 100 \times 8.2757 = \text{nearly } 2.05 \text{ per cent.}$$

Such small variations of conditions would be required to make the evaporative economies equal that, for all practical purposes, the results may be regarded as identical.

[Correspondents sending us inquiries should sign their communications with full names and post-office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

License Legislation in the United States*

By A. A. Potter†

Thirty-four states have no state laws at present and no proposed state legislation for licensing stationary engineers. They are: Alabama, Arizona, Arkansas, Colorado, Connecticut, Florida, Georgia, Idaho, Iowa, Kentucky, Louisiana, Maine, Maryland, Michigan, Mississippi, Missouri, Nebraska, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Tennessee, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin and Wyoming.

Nine states—California, Delaware, Illinois, Indiana, Kansas, Minnesota, Pennsylvania, Rhode Island and Texas—had laws pending in 1915. Charles H. Wirmel, chairman of the N. A. S. E. License Committee, asserted that a state law is pending in Washington. I have been unable to secure from the secretary of state at Washington any confirmation that such a law is before their legislature.

In Indiana an attempt has been made several times to have a state license law passed, but without success. The manufacturers, farmers, and even many of the operating engineers fought the bills introduced.

Several unsuccessful efforts were made to enact a state law in Missouri, but nothing was brought up at the 1915 session of the legislature. The State of New Hampshire has certain laws regarding engineers operating steamboats.

North Dakota, in Sec. 8994 of the 1905 Revised Codes, holds the engineer or other person having charge of steam boilers and engines responsible and guilty of a misdemeanor for accidents whereby human life is endangered.

The states having city laws include Alabama, California, Colorado, Connecticut, Indiana, Iowa, Illinois, Louisiana, Maryland, Michigan, Nebraska, New Jersey, New York, Pennsylvania, Tennessee, Washington and Wisconsin. These laws were given in detail in the "Report of the License Committee of the N. A. S. E." in 1906.

The act of the general assembly of the State of Louisiana empowers municipalities of over 50,000 inhabitants, through their local councils, to regulate the use of stationary and portable steam boilers, and to constitute and appoint a board of examiners of stationary and portable steam-boiler engineers for the carrying out of this purpose . . . empowers said municipalities to require persons operating steam boilers . . . , to have in their possession and posted in conspicuous places in the engine room where employed as such, certificates of authority . . . This act further requires owners to have none but certified engineers, having proper certificates and renewals thereof.

Missouri has at present the following law: "No person is authorized to manage, control or take charge of or act as engineer of any steam boiler, engine or apparatus, who has not the requisite knowledge or ability to manage the same with safety to the lives and property of the inhabitants of such cities. Any incorporated association of qualified local steam engineers in any city is authorized to appoint an examining committee for the granting of certificates of qualifications." Provision is also made that no charge exceeding one dollar is to be made for any certificate.

The State of Maine has certain laws pertaining to school buildings, churches or other public buildings when heated by a steam plant located in, under or near such building.

EXISTING AND PROPOSED LAWS

Examiners—The state license laws are under the jurisdiction of the boiler-inspection department of the District Police in Massachusetts. In Montana the state boiler inspectors attend to the licensing of engineers. In Nevada the boards of county examiners regulate the operation of stationary and hoisting engines. The state laws of Nevada are not very extensive or definite, but aid in protecting life and property. The district examiners, who are under the Industrial Commission of Ohio, examine applicants for licenses, while in New Jersey this power is vested in a bureau of the Department of Labor, known as the "Steam Engine and Boiler Operators' License Bureau." In Minnesota 53 inspectors are appointed by the governor and these examine engineers, issue licenses and inspect boilers. This system makes it possible to build up quite a political patronage. A new bill has been introduced into both branches of the Minnesota legislature this year which is indorsed by the Minnesota State Association of the N. A. S. E., the main features of which will be brought out later.

Among the states having proposed state license laws in 1915, California, Illinois and Pennsylvania have an examining board consisting of one chief engineer and several assistant examiners. In Indiana an examining board is appointed by the governor, but this board is under the supervision of the chief inspector of the State Bureau of Inspection, who is ex-officio the president of the examining board. In California the examining board is appointed by the commissioners of the Bureau of Labor Statistics. In Minnesota and Texas one examiner is appointed for each congressional district. The contents of the bills for Delaware and Rhode Island could not be secured. The proposed state law of Kansas vested the licensing power in an "Engineers License Committee."

In the majority of states a person to be eligible as examiner must have ten to fifteen years of practical experience.

License Required—Those exempted from license requirements include operators of locomotives, motor road vehicles, boilers in private residences, boilers and engines under the jurisdiction of the Government of the United States, boilers carrying not more than 15 lb. pressure, boilers and engines (stationary and traction) when used for agricultural purposes exclusively.

In Illinois and New Jersey the exemptions include boilers carrying not more than 10 lb. pressure and in Illinois only heating plants which serve 50,000 sq.ft. radiation or less. In California boilers less than 4 hp. and also those used in logging camps or in pumping or boring wells for oil or water are exempted. The proposed bill of Indiana and Ohio exempts boilers used in the production of crude oil. In some states the existing or proposed laws exempt only such heating boilers as are provided with a device approved by examiners, limiting the pressure to 15 lb. Apartment houses to be exempt must have less than five flats. In several states fire-department engines are exempt.

The exemption limit for boilers and engines is 9 hp. in Massachusetts, 30 hp. in Ohio and Pennsylvania, and 250 hp. in Texas. In Texas this high limit is fixed in order to exempt all ginners, contractors and sawmills of the state. In Pennsylvania first- and second-class cities are exempt from the state license act, such cities having municipal license laws.

Classification of Licenses—Several of the proposed bills seem to be in favor of making no differentiation between grades or classes of engineers. California, Indiana, Illinois, Nevada, New Jersey and Pennsylvania have such bills in force or proposed. A large number of the cities of the first class have unclassified license laws, the opinion being that the license law is mainly for the protection of life and property.

The Massachusetts license law includes four different classes of engineers' licenses, three classes of firemen's licenses and a special license for particular plants.

The proposed law of Minnesota calls for four classes of engineers' licenses and also a special license for portable, traction or agricultural engines.

In Montana there are three classes of engineers' licenses and a traction-engine license. Firemen not under the direct charge of an engineer are required to have a third-class license.

Ohio classifies engineers' licenses into first, second and third grades. These licenses are granted partly upon the percentages received in the examination, as will be explained in the next section.

The Texas bill grades engineers into three classes—first, second, and special. The owner or lessee is held responsible for the engineer carrying a special license.

The proposed Kansas bill provided for two grades of engineers' licenses.

Requirements for Licenses—All proposed state bills make provision for issuing licenses to engineers engaged in the practice of their occupation at the time the licensing act takes effect.

In Massachusetts where the licenses are classified, to be eligible for a first-class fireman's license a person must have been employed as a steam engineer or fireman in charge of or operating boilers for not less than one year. The third-class engineer's license requires one and one-half years' ex-

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*Paper presented before the Kansas State Convention of the National Association of Stationary Engineers at Wichita, on May 14, 1915.

†Dean of the Division of Engineering and Professor of Steam and Gas Engineering at the Kansas State Agricultural College.

perience, the second-class engineer's license two years' experience in a plant having at least one engine of over 50 horsepower. A person who has served an apprenticeship for three years to the machinist or boiler-making trade or is a graduate of a recognized engineering college, is eligible to take the second-class engineer's examination if he has been employed for one year in connection with the operation of a steam plant. Three years' experience in a power plant having at least one engine of 150 horsepower is the requirement for first-class license examination.

The proposed act of Minnesota requires five years' experience for first-class license, three years' experience for second-class, and one year's experience for third-class license.

In Montana the requirements are three years' experience for first-class license, two years' experience for second-class license, and one year's experience for third-class license.

In Ohio a first-class license is granted to applicants who have had three years' practical experience and who obtain a percentage of 85 or more in the examination. Two years' experience and a percentage rating of from 70 to 84 entitle the applicant to a second-class license, while the third-grade applicant must have one year's experience and an examination rating of from 60 to 69.

No definite requirements were outlined for the two grades of licenses in the proposed Kansas bill.

A clause should appear in bills or acts giving special authority to representatives or erecting engineers of any manufacturers of boilers or engines when employed in installing, testing, or operating boilers or engines.

Fees for Licenses—Illinois and Ohio, $2 for license and $2 for yearly renewal. California, Nevada and Texas charge $5 for license. Nevada has no renewal requirement, while California and Texas charge annual renewal fees of $2 and $5 respectively. The proposed law of Pennsylvania has $3 for license and $1 for renewal. In Montana the charges are: $7.50 for first-class license, $5 for second-class, $3 for third-class and special, and $1 for yearly renewal for all grades. The proposed Kansas law provided for $5 fee in the case of first-class license, $3 for second-class, and yearly renewal charges for the two classes $3 and $2 respectively.

The present Minnesota law allows the inspector to grant licenses for a fee of $1, which he pockets. The proposed law includes $2 for examination and $1 for annual renewal.

Appeal from Refusal of License—A person who is aggrieved by the action of an examiner in refusing or revoking a license has the right of appeal therefrom in all states except in Massachusetts, where the action of the examining board is final. In several states the applicant has the privilege of having one outside person during the examination or during the hearing of an appeal. This person is not allowed to take part, but can take notes if he so desires.

Posting of License—In the majority of states the act requires that the engineer's or the firemen's license be placed in a conspicuous position in the engine room of the plant operated by the holder of such license.

Operation without License—In Massachusetts a person without a license is allowed to operate a plant for one week, in Pennsylvania ten days and in Montana for a period of fifteen days, provided notice to that effect is sent to the inspector. In the majority of cases no provision is made authorizing operation without license.

Records of Operation—The Massachusetts law requires "a daily record of the boiler, its condition when under steam and all repairs made and work done on it" upon regular printed forms furnished by the boiler-inspection department.

Boiler Inspection—The states of Colorado, Connecticut, Massachusetts, Minnesota, Montana, Nevada, New York, Ohio, Pennsylvania and Wisconsin have boiler-inspection laws. In Colorado the governor appoints a chief and three deputy boiler inspectors who test every stationary boiler annually. The same is the case in Connecticut, where a boiler inspector is appointed from each congressional district.

In Massachusetts and in Ohio, besides the boiler-inspection department, which is responsible for the inspection of boilers, there is a "Board of Boiler Rules." The chief inspector of the boiler-inspection department is the chairman of the board of boiler rules, the other members being selected to represent the boiler-using interests, the boiler-manufacturing interests, the boiler-insurance interests and the operating engineers. The board of boiler rules formulates rules for constructing, inspecting, installing and testing of boilers.

Montana seems to have had boiler-inspection laws for many years. The 13th Biennial Report of the state boiler inspector shows that even in such a large and thinly populated state as Montana the boiler-inspection department has not only been self-sustaining, but has produced a revenue for the state, over all expenses, of nearly $16,000. The state has no record of a serious boiler explosion.

In New York the state fire marshal has charge of boiler inspection.

[This office has been discontinued and the duties of boiler inspection transferred to the factory inspector.—Editor.]

In Wisconsin boiler inspection is under the Industrial Commission, which has a standard code of rules for the construction, operation and inspection of boilers. This commission accepts inspections from qualified inspectors in cities of the first, second, and third class.

The fees for boiler inspection are, in the majority of states, $5 for external and internal inspection of each boiler and $2 when the boiler is only externally inspected under steam pressure. In Connecticut provision is made for inspecting steam boilers owned by farmers, once in two years for a fee of $2, provided such boilers do not exceed 5 hp. each. In Montana a charge of $10 is made for the inspection of a single boiler and $5 for each additional boiler.

The present law of Minnesota allows the inspectors to charge $3 for each boiler inspection and to keep such fees. The proposed law of Minnesota places a fee of $3 for the inspection of a single boiler and $2 for the inspection of each additional boiler.

In this connection the recent act before the 1915 Pennsylvania legislative session is of some interest. This act requires municipal inspection of steam and hot-water installations and provides for the examination, licensing and registration of persons, firms or corporations engaged in the business or work of steam and hot-water fitting.

DISPOSITION OF 1915 BILLS

It may be of interest to report the status of the bills proposed in 1915: The Kansas bill was killed in the committee. The Delaware, California, and Rhode Island bills were lost. The proposed license-law bill of Pennsylvania was declared unconstitutional by the attorney-general, principally on account of its exemptions. An act for the licensing of engineers in third-class cities of Pennsylvania passed through the committee and it is understood has a good chance of passing the House. In accordance with this bill, the city council appoints an examining board, consisting of two engineers who have had not less than six years' practical experience, to act in conjunction with the director of public safety. The proposed engineers' license and boiler-inspection law of Minnesota was defeated in the Senate on Feb. 18, after much hard and creditable work on the part of the Minnesota State Association of the N. A. S. E. No definite information could be secured regarding the ultimate fate of the bills proposed in Illinois, Indiana and Texas.

Powdered Coal

At the seventh annual convention of the International Railway Fuel Association, W. L. Robinson, supervisor of fuel consumption of the Baltimore & Ohio R.R., read an interesting paper outlining the advantages that might result from the use of powdered coal in locomotive furnaces. The cost of fuel for the 65,000 steam locomotives in use in the United States is from $250,000,000 to $275,000,000 per annum, and now represents about 25 per cent. of the total transportation-account expenses. The fuel used is principally bituminous coal, anthracite, fuel-oil, lignite and coke. While powdered coal has been used successfully and rather extensively for years in cement and metallurgical furnaces, its use for steam-making purposes has been limited, owing to the lack of practical development. Its possibilities, however, are great, and if the practical difficulties can be overcome, the saving for the various railroad companies throughout the country will be on a corresponding scale.

Coal in a finely divided or powdered state represents the most advanced method for producing perfect combustion. While a cubic inch of solid coal exposes only 6 sq.in. for absorption and liberation of heat, a cubic inch of powdered coal exposes from 20 to 25 sq.ft., which enables the more uniform gas production from the volatile matter in the coal and the more prompt and perfect intermingling of gas and air, thereby improving combustion and reducing smoke. Furthermore, there is no cooling of the fire by heavy intermittent charges of fresh coal, as is the case with hand or stoker firing on grates.

It has been generally thought that for the burning of solid fuels in powdered form in suspension, a bituminous coal of less than 30 per cent. volatile matter could not be used with satisfactory results. Mr. Robinson, however, had been informed that good results were being obtained in locomotive practice from semibituminous coal analyzing as low as 21 per cent. volatile and having 15 per cent. ash and moisture. To give the best general results and the least trouble from ash and slag, powdered coal should contain not more than 1 per cent. moisture and be of a uniform fineness, so that

not less than 95 per cent. will pass through a 100-mesh, not less than 85 per cent. through a 200-mesh, and not less than 70 per cent. through a 300-mesh screen.

COST OF POWDERING

The cost of preparing powdered coal will vary with the cost for the raw coal and its moisture content. However, a general average from available data covering periods of the past five to ten years at cement and metallurgical plants has made it possible to present the following conservative estimate, assuming the cost of the raw coal at from $1 to $2 per short ton, and that it will require crushing and have a moisture content of from 5 to 10 per cent. when placed in the drier:

Capacity of Plant in Short Tons per Hour	Average Total Cost for Preparation per Short Ton
2	From 25 to 50 cents
3	From 20 to 45 cents
4	From 16 to 40 cents
5	From 14 to 35 cents
10	From 12 to 30 cents
25	From 10 to 20 cents

The fuel required for drying the coal will average from 1 to 2 per cent. of the coal dried. The distribution of the total may be approximately stated as follows:

Fuel for drying	10 per cent.
Power for operation	30 per cent.
Labor	30 per cent.
Maintenance and supplies	25 per cent.
Interest, taxes, insurance and depreciation	5 per cent.
Total	100 per cent.

The cost of preparing powdered coal should be more than offset by the ability to utilize mine refuse and sweepings, run-of-mine, screenings and slack grades of coal that cannot be used to good advantage otherwise, and inferior grades of sub-bituminous coals, lignite and peat of relatively lower cost per ton than the readily salable commercial fuels.

Powdered coal may be burned by either of two generally defined methods—the long-flame method, constituting a progressive burning of the coal such as is employed in cement and openhearth furnaces, and the short-flame method, which is the latest development and is used in metallurgical and similar metal-heating work or under boilers where a similar furnace volume obtains. A combination of the long- and short-flame methods has been tried recently on a New York Central locomotive equipped for burning powdered coal.

LOCOMOTIVE MODIFICATIONS REQUIRED

For locomotive work the principal requirements are an inclosed fuel container, means for conveying the fuel to the feeders, means for commingling the fuel with air at the time of feeding, and afterward equipment for supplying the proper amount of air to produce a combustible mixture at the time the fuel and air finally enter the furnace, a suitable refractory-material furnace in the firebox, means for disposing of the slag, means for producing the proper draft through the furnace and boiler, means for harmonizing the draft and the combustion, suitable power for operating the fuel- and air-feeding mechanism, and automatic and hand control of the fuel and air regulation.

It is understood that the developed equipment for burning pulverized fuel can be readily applied to all existing modern types of steam locomotive without any changes in the boiler except to install arch brick supporting tubes, where fireboxes are not now equipped, and to remove the grates, ashpan and smokebox draft appliances. There is no equipment in the cab except the automatic hand control, which is placed in a position convenient to the fireman. The inclosed fuel container is suitable for either powdered coal or fuel oil and either kind of fuel can be used by changing the feeding equipment. The total weight of equipment applied will about equal that of the equipment removed. When not in operation the necessary draft through the boiler is obtained by the usual stack steam blower, and by exhaust steam from the cylinders when the locomotive is working. The supply of fuel is regulated according to the work the locomotive is performing, and when drifting or standing on sidings or at terminals, it can be entirely shut off. The exhaust-nozzle opening is about double the area of that used for grate firing.

Some of the advantages enumerated were the sustained boiler horsepower obtained from the use of powdered coal, the ability to increase the economical length of run, the firing of the boilers automatically with no hand-labor, the prevention of cinders, sparks, and smoke; the reduction in cylinder back-pressure due to the enlarged exhaust passages; saving in inspection, maintenance and operation through the elimination of grates, ashpans, dampers, etc.; a more uniform furnace temperature, reducing the liability of firebox and flue leakage; ability to make use of inferior qualities and grades of solid fuel; reduction of delay from cleaning or dumping fires; and a number of other factors which would tend to improve efficiency and lower the cost per car-mile.

DISCUSSION OF THE PAPER

The paper aroused a great deal of interest, and the subject was considered of enough importance to appoint a permanent committee to keep posted on developments in this field. In the discussion some of the difficulties experienced in burning powdered coal were brought to light. The principal objection and the most serious factor interfering with the continuous operation of the locomotive was the formation of large quantities of slag, which clings to the boiler plates, fills up the tubes and forms on the superheating surface. E. H. Stroud, a maker of powdered-coal equipment, who has had considerable experience in an experimental stationary plant equipped for burning powdered fuel, explained that there were several essential factors which must be given attention to burn this coal successfully. First, it is necessary to powder the coal to the proper fineness. This is vital, because instantaneous ignition within a few inches of the burner must be obtained. Unless complete combustion is obtained at once, slag will form. The furnace must get the proper amount of air, and to insure a correct mixture mechanical means to measure the coal and air are required. Slag was an objectionable feature, but there is no occasion to permit it to get as far as the boiler tubes. All of this could be precipitated in a chamber formed by a specially constructed arch at the rear of the firebox. It was his conviction that it paid to dry the coal. This could be done while it was being pulverized. The cost of pulverizing, including power, wear and tear and attendance, at a rate of 5 to 10 tons per hour, should not exceed 15c. per ton. Drying would add 4 to 6c. per ton. As to a capacity of individual units, burners could be made which would burn as low as 15 lb. per hour and as high as 5000 lb. per hr.

Joseph Harrington, who has recently become associated with the Powdered Coal Engineering & Equipment Co., of Chicago, discussed the question from the standpoint of smoke abatment. In Chicago and many other municipalities electrification has been urged because it eliminates smoke, soot, cinders, sparks and excessive noise. Within the City of Chicago alone the cost to electrify the railroads has been estimated at $190,000,000. It would appear that the same results can be obtained by the use of powdered coal, at a cost which would be insignificant in comparison. A uniform system would be maintained on the railroads and according to an estimate by Mr. Robinson, the use of powdered coal would result in a saving on various heat losses alone of 25 per cent. This does not include savings from the prevention of smoke, soot, cinders, sparks, ash-handling, the use of inferior grades of soft coal, elimination of smoke inspectors, which in Chicago alone costs the railroads $65,000 per annum, and the solution of other problems that enter into the production of steam power in locomotives.

Potential Hydro-Electric Development in Ontario, Canada

It is conservatively estimated that within a radius of fifty miles from Ottawa, there is available water power of approximately one million horsepower. The Ottawa River alone would supply 700,000, and its tributaries 300,000 horsepower. This estimate is based upon an average of water obtainable throughout the year from twelve to fourteen rivers. In this section are many great lakes that can be converted into immense reservoirs. A number of dams have been built on the upper reaches of the Ottawa River, insuring when fully completed a steady supply of water throughout the year.

Eminent authorities, when calculating the relative cost of hydro-electric and steam-generated energy, place the latter on the basis of $25 per horsepower year. Estimating the cost of the same power generated by water at $10 yearly, the saving effected for an output of one million horsepower would be fifteen million dollars. This power is all within a short distance of Ottawa, and therefore can be transmitted to that city very economically. The accompanying table was prepared by Holgate, McDougall and Ker, well-known civil and hydraulic engineers, acting as a special commission for the City of Ottawa. The data relate to existing installations within thirty miles of the city.

Name of Power Site	Distance (Miles) of Trans.	Hp. Output of Sub-station	Cost per Hp. per Year
Metropolitan Company	7	5,100	15.73
Metropolitan Company	7	11,050	13.89
Gatineau River	7	5,000	13.60
Gatineau River	7	10,000	8.80
Gatineau River	7	20,000	6.50
Lievre River	30	5,000	13.95
Lievre River	30	10,000	9.13

Lievre River	30	20,000	6.99
Lievre River	30	30,000	6.06
Chats Falls	30	5,000	13.20
Chats Falls	30	10,000	9.20
Chats Falls	30	20,000	7.80

Another section offering a splendid opening for enterprising capitalists to develop and exploit its water powers and industrial resources is the Sault Ste. Marie district. The Canadian share of the great falls on the "Soo" is yet undeveloped, while with the several falls on the Michipocoten River and the Steep Hill Falls on the Magpie River, there is easily 100,000 horsepower in the immediate vicinity. In the district to the north, millions of dollars worth of iron and other natural resources, the great spruce forests of the clay belt and an unlimited pulpwood area are awaiting development.

Committee on Classification of Technical Literature

Delegates from about twenty national technical and scientific societies met at the Engineering Societies Building, New York, on May 21 to perfect a permanent organization, the purpose being to prepare a classification of the literature of applied science which might be generally accepted and adopted by these and other organizations. It was the feeling of the meeting that such a classification, if properly prepared, might serve as a basis for the filing of clippings, for cards in a card index, and for printed indexes; and that the publishers of technical periodicals might be induced to print against each important article the symbol of the appropriate class, so that a file might be easily made which would combine clippings, trade catalogs, maps, drawings, blueprints, photographs, pamphlets, and letters, classified by the same system.

By request, W. P. Cutter, librarian of the Engineering Society's Library, read a paper on "The Classification of Applied Science," and after describing the existing classifications, stated that in his opinion no one of these was worthy of general adoption. He outlined a plan whereby a central office could collect all the existing classifications and with the help of the various national societies interested might compile a general system which, although not absolutely perfect, might be generally accepted.

The following societies were represented by delegates: United Engineering Society, American Foundrymen's Association, Society for Electrical Development, American Ceramic Society, American Institute of Architects, American Society of Agricultural Engineers, American Society of Refrigerating Engineers, American Gas Institute, American Water-Works Association, American Society of Mechanical Engineers, National Fire-Protection Association, American Society of Heating and Ventilating Engineers, Society of Automobile Engineers, Society for the Promotion of Engineering Education, United States Bureau of Standards, American Physical Society, Franklin Institute, American Institute of Mining Engineers, American Society for Testing Materials, National Electric Light Association, American Electro-Chemical Society, Illuminating Engineering Society, and American Railway Engineering Association.

The name adopted for this organization is "Joint Committee on Classification of Technical Literature." A permanent organization was effected by the election of the following executive committee: Fred R. Low, chairman; W. P. Cutter, 29 West 39th St., New York, secretary; Edgar Marburg, H. W. Peck and Samuel Sheldon.

Meeting of Engineering Foundation

The Engineering Foundation held its first regular meeting May 25, and selected a board to administer the trust founded by Ambrose Swasey, as described in our Feb. 2 issue. The board consists of Charles Warren Hunt and J. Waldo Smith, representing the American Society of Civil Engineers; Dr. Alexander C. Humphreys and Jesse M. Smith, American Society of Mechanical Engineers; Dr. A. R. Ledoux and Benjamin D. Thayer, American Institute of Mining Engineers; Charles E. Scribner and Dr. M. I. Pupin, American Institute of Electrical Engineers; Edward D. Adams and Howard Elliott, representing the general public. The officers elected were: Gano Dunn, chairman, by virtue of his office as president of the United Engineering Society; Edward D. Adams, vice-chairman; F. R. Hutton, secretary, and Joseph Struthers, treasurer.

A large number of applications have already been received from those who want to use the funds for research work. Because of the number of applications and the incomplete form in which many of them were received, a schedule of requirements for applicants is being prepared by the following committee, which was chosen by the board: Dr. A. R. Ledoux, chairman; J. Waldo Smith, Dr. M. I. Pupin and Dr. Alexander C. Humphreys.

Recent Court Decisions

Digested by A. L. H. STREET

Spread of Fire by Portable Engines—The law enacted by the Wisconsin Legislature in 1913, requiring traction and portable engines to be equipped with a "screen or wire netting on top of the smoke-stack and so constructed as to give the most practicable protection against the escape of sparks and cinders" and "with the most practicable devices to prevent the escape of fire from ashpans or fireboxes," has just been considered by the Supreme Court of the state in the case of Legro vs. Carley, 150 "Northwestern Reporter," 985. The court holds that the statute is sufficiently specific in its requirements to be valid, and that a spark arrester in a threshing machine, consisting of an inverted cone of screen wire, is not a sufficient spark arrester, if it has been permitted to remain unrepaired after the point of the apex has burned or rusted off.

Effect of Temporary Use of Gasoline Engine on Fire Risk—A clause in a fire policy reading, "This policy shall be void . . . if camphene, benzine, naptha or other chemical oils or burning fluids shall be kept or used by the insured, on the premises insured," does not invalidate the policy on account of the temporary use of a gasoline engine, especially where the insurance company must have contemplated such use of the engine. This is the holding of the Maine Supreme Judicial Court in the case of Bouchard vs. Dirigo Mutual Fire Insurance Co., 92 "Atlantic Reporter," 899. It appears that the defendant company issued to the plaintiff a policy containing the clause quoted, covering a farm house and barn, and denied liability for a loss because it resulted from using a gasoline engine in driving threshing machinery. But the court held that such use must have been contemplated when the policy was issued, and that the clause mentioned must be construed as applying to some permanent condition increasing the fire risk, and not to mere temporary use of a gasoline engine.

Responsibility for Employee's Negligence—The owner of a power plant is not liable for injury to a boiler company's inspector, resulting from negligence of an engineer employed by the owner, if, in undertaking to assist in the inspection, the engineer exceeded his authority. This, in effect, is the decision of the Illinois Supreme Court lately announced in the case of Johanson vs. Wm. Johnston Printing Co., 104 "Northeastern Reporter," 1046. The evidence showed that the boiler company was employed to inspect the boiler, which had been leaking, and sent the plaintiff to do the work. He went into the combustion chamber of the boiler, the fire having been drawn, and was scalded through leaking of hot water upon him. In his suit to recover for the injury, he relied upon the engineer's negligent failure to remain near the boiler as he had promised to do. The Supreme Court disposed of the case in the defendant's favor on the ground that the engineer was not authorized to assist in the inspection, and acted beyond the scope of his duties in so doing. The court said: "Outside of the scope of his employment, the servant is as much a stranger to the master as any third person, and an act of the servant not done in the execution of services for which he was engaged cannot be regarded as the act of the master."

Make Dinkel Steam Trap—We are informed by the Schütte & Koerting Co., Twelfth and Thompson Streets, Philadelphia, Penn., that they also manufacture the Dinkel steam trap, a description of which was published on page 644 of the May 11 issue.

At a Meeting of the American Physical Society, Prof. C. W Chamberlain, of Denison University, Granville, Ohio, presented and demonstrated his compound interferometer, by which it is possible to measure 0.00000005 of an inch. It is next to impossible for the human mind to conceive the minuteness of a measurement of this kind. It is equal to the apparent size of the head of an ordinary pin viewed at a distance of 227 mi. or the size of a silver dollar viewed at a distance of 9000 miles. —"American Machinist."

ENGINEERING AFFAIRS

The Association of Iron & Steel Electrical Engineers will hold its annual convention at the Hotel Statler, Detroit, Mich., Sept. 8-11. Suggestions regarding arrangements and inquiries regarding accommodations should be addressed to A. H. Swartz, Chairman Convention Committee, Churchill Ave., Cleveland, Ohio.

The American Society of Civil Engineers has adopted resolutions providing that its representatives shall confer with the Federal authorities on the plan by which a reserve corps of army engineers shall be developed from its membership. The resolutions state that these men are not only seasoned in all lines of organization and constructive work, but are also closely in touch with the best workers from whom the rank and file of all branches of military service can be drawn. A committee has been appointed to take up with the War Department the plan of organizing this corps.

International Engineering Congress—The materials of engineering construction will receive special attention in the proceedings and discussions of the International Engineering Congress to be held in San Francisco, Sept. 20-25. The field will be treated under 18 or more topics, covering: Timber resources; preservative methods; brick and clay products in general; life of concrete structures; aggregates for concrete; waterproofing; volume changes in concrete; world's supply of iron; life of iron and steel structures; special steels; status of copper and world's supply; alloys; aluminum; testing of metals, of full-sized members, and of structures. These papers, with discussions, will be published as Volume 5 of the "Transactions," and will be illustrated. For full particulars apply to W. A. Cattell, secretary, 417 Foxcroft Building, San Francisco, Calif.

NEW PUBLICATIONS

MATERIALS OF MACHINES—By Albert W. Smith, Director of Sibley College, Cornell University. Published by John Wiley & Sons, Inc., New York. Size, 5x7 in.; 215 pages; 36 diagrams. Price, $1.25.

In the second edition, which has been entirely rewritten and considerably enlarged, Professor Smith's little book gives an elementary view of the manufacture and properties of iron, steel, copper, lead, tin, zinc, aluminum and the brass and bronze alloys. The first part of the book gives a brief outline of the metallurgy of the materials. It also takes up fuel combustion, the types of electric furnaces and the refractory materials used in lining metallurgical furnaces. The second part relates to chemical and mechanical properties, and includes chapters on testing materials, on the heat treatment of steel, and on brass and bronze alloys. The book is self-contained and the reader need not consult chemistries, metallurgies and works on strength of materials in order to use the information.

VOCATIONAL MATHEMATICS—By William H. Dooley, Principal of Technical High School, Fall River, Mass. Published by D. C. Heath & Co., New York. Size, 5x7 in.; 341 pages; illustrated. Price, $1.

The author has prepared this book for use in vocational schools, in which it is necessary to impress students with the direct application of their mathematical knowledge to trade and industry. After a review of the essentials of arithmetic and mensuration, problems peculiar to the carpenter, plumber, steam engineer, electrician, machinist and to the sheet-metal and textile worker are presented. To illustrate the method followed, the chapter devoted to engines contains an illustrated description of simple vertical and horizontal engines, of the indicator, methods of calculating horsepower, mean effective pressure from indicator cards, flywheel weight, steam lap and size of supply pipes. Of course, the derivation of the formulas is not given, but their application and problems relating to them are given. Much of the technical information has no bearing on mathematics, and in addition is not always correct. Such errors as the expression of latent heat in degrees and the labeling of a series as a parallel circuit should have been avoided.

PUBLICATIONS OF THE BUREAU OF MINES

Bulletin 88: The Condensation of Gasoline from Natural Gas. By G. A. Burrell, F. M. Seibert, and G. G. Oberfell; 1915; 106 pp., 6 pls., 18 Figs.

Technical Paper 101: Permissible Explosion-Proof Electric Motors for Mines; Conditions of Tests and Requirements for Test and Approval. By H. H. Clark; 1915; 17 pp., 2 pls., 1 Fig.

A limited supply of these papers is available for distribution to those interested. They should be ordered by number and title from the Director of the Bureau of Mines, Washington, D. C.

TRADE CATALOGS

Dodge Sales and Engineering Co., Mishawaka, Ind. Catalog. Gearing. Illustrated, 126 pp., 6x9 in.

B. F. Sturtevant Co., Hyde Park, Boston, Mass. Bulletin No. 218. Vertical engines. Illustrated, 16 pp., 6½x9 in.

Yarnall-Waring Co., Chestnut Hill, Philadelphia, Penn. Bulletin C. A. Simplex-Caskey valves for hydraulic service. Illustrated, 4 pp., 6x9 in.

Link-Belt Co., Philadelphia, Penn. Book No. 210. Wagon and truck loaders for handling coal, coke, stone, sand, etc. Illustrated, 48 pp., 6x9 in.

SKF Ball Bearing Co., 50 Church St., New York. Bulletin No. 25. SKF Ball bearings in machine tools and shop equipments. Illustrated, 68 pp., 6x9 in.

Smooth-On Mfg. Co., 572-74 Communipaw Ave., Jersey City, N. J. Pamphlet No. 4. Smooth-On Iron Cement No. 7 for water-proofing brick ad concrete construction. Illustrated, 4 pp., 6x9 in.

The Jeffrey Mfg. Co., Columbus, Ohio. Bulletin No. 165. Wagon and truck loaders for sand, gravel, etc. Illustrated, 16 pp., 6x9 in. Bulletin No. 166. Wagon and truck loaders for bituminous and anthracite coal. Illustrated, 24 pp., 6x9 in.

BUSINESS ITEMS

The American Pin Co., of Waterbury, Conn., has recently ordered from the Builders Iron Foundry, Providence, R. I., one large meter tube for boiler feed service. The Imperial Tobacco Co., of Montreal, Canada., has also ordered a 2-in. meter tube for the same service.

The Cooling Tower Co., with headquarters at No. 50 Broad St., New York, has been incorporated to handle the growing demand for the well-known "Mitchell-Tappen" cooling towers, the patents on which are now controlled by the new company, which also has additional patents pending. The operations of the company will not be confined to cooling towers alone but where the purchasers' manufacturing conditions warrant it the new company is prepared to design and install spray-nozzle systems and other cooling devices for the economical re-cooling of liquids from all forms of condensing, refrigerating, smelting or gas engine plants.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance

Positions Open. (Civil Service Examinations), **Employment Agencies** (Labor Bureaus), **Business Op portunities, Wanted** (Agents and Salesmen—Contract Work), **Miscellaneous** (Educational—Books), **For Sale**, 5 cents a word, minimum charge, $1.00 an insertion.

Count three words for keyed address care of New York; four for Chicago Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A.M. Tuesday for ensuing week's issue Answers addressed to our care, Tenth Ave. at Thirty-sixth Street, New York or 1144 Monadnock Block, Chicago will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion. P

POSITIONS OPEN

MAN to sell heavily advertised power-plant specialties in New York; must have knowledge of power-plant equipment; an engineer will be considered; position permanent to right man with old-established house. Write full particulars, giving salary desired and past connections. P. 518, Power.

POSITIONS WANTED

ENGINEER, experienced in alternating and direct motors and generators, engines, turbines and ice machines; A-1 references. P. W. 521, Power.

CHIEF ENGINEER, employed in central station; seven years' experience with engines, turbines, dynamos, boilers; married; age 30. P. W. 511, Power, Chicago.

TECHNICAL GRADUATE, Middle West university, mechanical engineering, two years' practical experience, desires position with progressive firm. P. W. 524, Power.

MASTER MECHANIC, 28, twelve years' experience with steam engines (all types), boilers and general machinery; knowledge of theory and practice in mechanical and electrical engineering; excellent references. P. W. 514, Power.

A CAPABLE ENGINEER at present employed as chief engineer in a modern plant desires change where opportunity for further advancement is greater; can furnish references as to character, ability, etc. P. W. 512, Power.

CHIEF ENGINEER, technical education, broad experience, energetic, successful in handling plants and men, open for engagement July 1; desires responsible position; best of references as to ability and character; age 42. P. W. 522, Power.